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for the drilling-producing-pipe line industry

PETROLEUM REFINER and The REFINERY CATALOG
for the refining-natural gasoline industry

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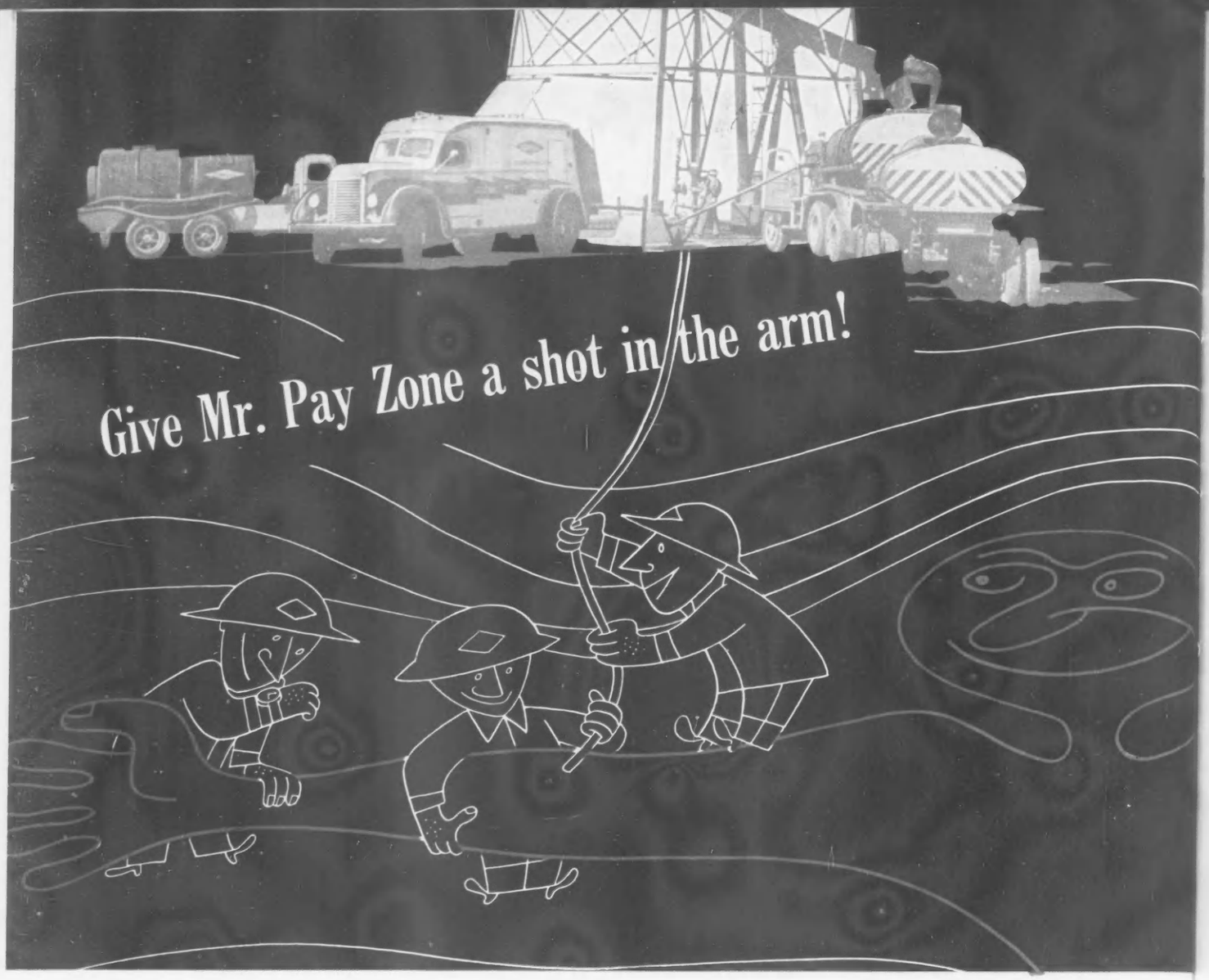

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Editor's Page

ONCE AGAIN the U. S. has more than enough oil to meet current consumption requirements. So great was the volume produced and refined during the closing months of 1948, oil stocks rose sharply to quite high levels. Sudden easing of the oil supply situation has brought production cutbacks and some reductions in refined product prices.

PRESENT CONDITIONS, however, should not be viewed with the alarm and pessimism that prevails in many quarters.

WHAT'S HAPPENED is that prewar conditions in the oil world are fast returning, and it should be remembered that prior to the war the American oil industry normally operated with more than enough oil to go around.

THE OUTLOOK is far from discouraging. After having increased all its operations to the highest levels in history during 1948, the U. S. petroleum industry will encounter even larger demand for its products in 1949. Faced with prospects of record-breaking consumption in 1949, crude oil production, natural gasoline production, refinery runs, drilling operations and other activities are all likely to attain higher peaks than ever before. Even the more pessimistic forecasts of demand foresee very large volumes of oil.

PRESENT OIL STOCKS need not prove seriously burdensome, although further increases unquestionably should be avoided. An increase in inventories over prewar levels obviously was required by enlarged consuming rates, expanded transportation, refining and distribution facilities, all of which necessarily require additional working stocks. Moreover, the changed pattern of petroleum consumption necessitates far bigger accumulations of fuel oil stocks to provide for larger winter heating oil requirements. Although the year-end level of stocks of all oils was the largest since 1931, they were equivalent to only 99 days' supply on the basis of demand during the past year. Until storage volumes were depleted during the war, the industry's stocks were equivalent to many more days of supply. For example, stocks at the end of 1941 were equivalent to 127 days' supply.

MORE STRINGENT PRORATION of production must be reinstituted as an everyday policy, if stocks are not to be enlarged further to excessive levels. However, the necessity of imposing stricter production limitations should not be viewed with alarm. The outlook is not as dark as it seems at the moment. In the first place, this was the normal situation before the war, and producers operated successfully under such conditions. Furthermore, if estimates of demand for petroleum products in 1949 are fairly accurate, there should not be any serious and sustained cutback of U. S. production.

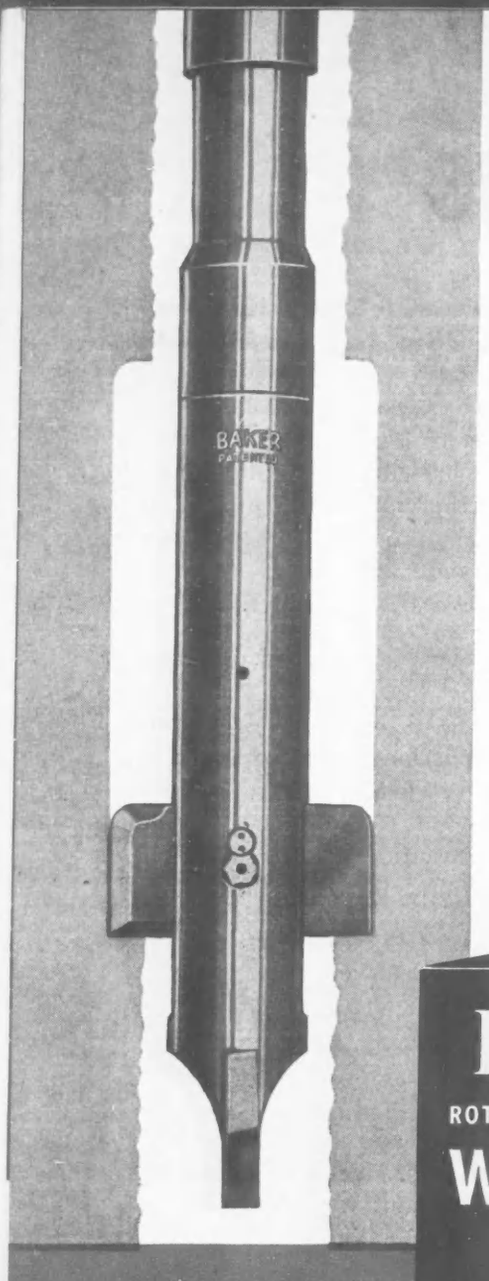
TO THE CONTRARY, it is indicated that production of crude in the U. S. for the year as a whole will be at or near all-time peak levels during 1949. Crude production undoubtedly is at its low level of the year right now, and producers can look forward to steadily enlarged allowables in coming months. More crude than currently is being produced will be needed to balance supply with estimated larger consuming rates later in the year.

FURTHERMORE, predicted production levels for 1949 reflect an amazingly large gain when contrasted with earlier years. Anticipated producing rates for 1949 will be 1¾ million barrels per day or 46 percent greater than the prewar peak of 3,842,000 barrels produced daily in 1941, and will be twice the quantity produced as recently as 1935.

THE CURRENT SITUATION should not cause discouragement. An oversupply is a normal thing for the oil industry of this country. In this way, the industry has always demonstrated that it is capable of meeting the needs of the American people, whatever they may be. Having more than enough oil to adequately supply all needs prevented establishment of federal government control many times in the past, and will do it again in the future. Furthermore, the rebuilding of producing ability to levels exceeding current requirements is essential from a national security viewpoint.

NORMALCY IS returning to the industry, and the present situation merely marks the return of normal conditions following the abnormal war years.

Warren L. Baker



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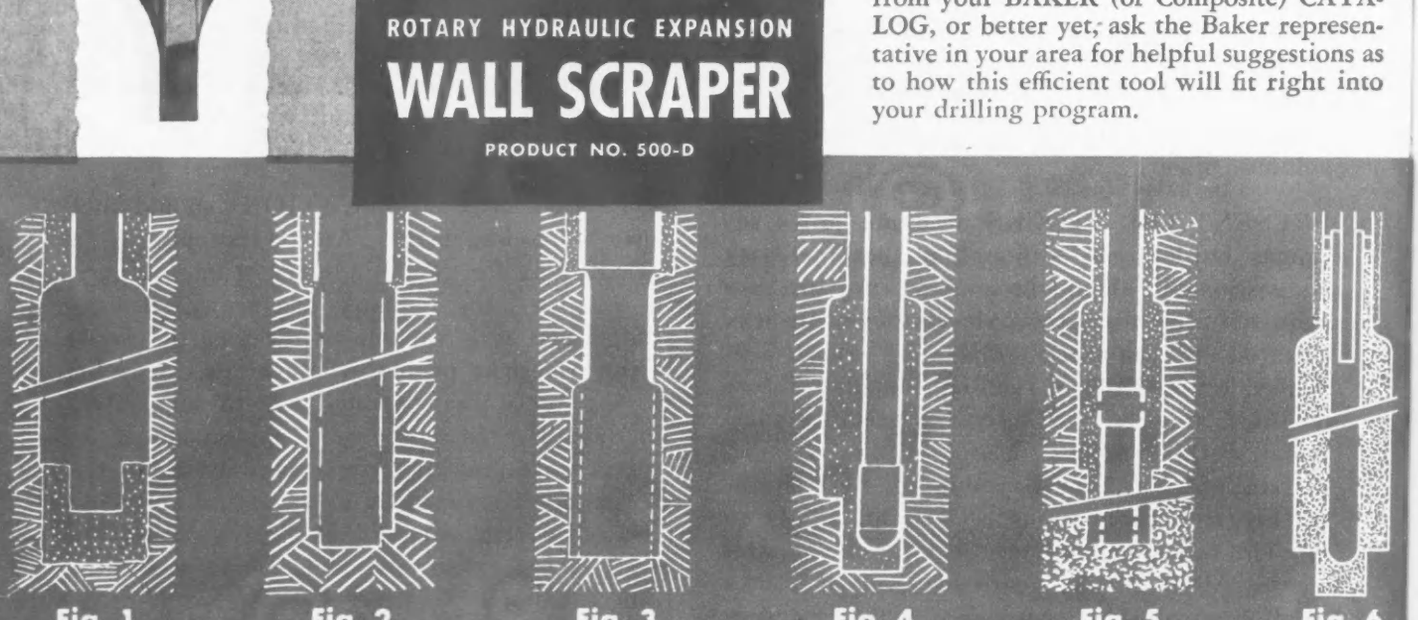

Fig. 1 Fig. 2 Fig. 3 Fig. 4 Fig. 5 Fig. 6

These typical uses illustrate a few of the many worthwhile applications of the Baker Rotary Wall Scraper.

Figure 1—WATER SHUT-OFF TESTS are made after rat-holing below the shoe, "wall scraping" for a vertical distance of 5 feet or more to the gauge of the original hole (or slightly beyond). Figure 2—ENLARGING HOLE TO SET CASING OR LINER with maximum ease and safety. Figure 3—REMOVING MUD SHEATH from the face of the formation to permit cement to bond with original formation. This same procedure is used to scrape the face of the oil sand to increase production. Figure 4—BOTTLENECKING to insure complete encasement of the shoe joint with cement; also to minimize hazard of channeling at this vital point. Figure 5—ENLARGING HOLE FOR C.P. JOB—showing "bottlenecked" section with casing or liner serving as water string above, and oil string below, the cementing point. Figure 6—GRAVEL PACKING is easily and effectively performed when the hole has been enlarged with a Baker Rotary Wall Scraper.

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The Changing Panorama

Reduction of Imports Likely

Reduction of petroleum imports into the U. S. is in prospect. Decreases in volumes of imports from both the Caribbean area and the Middle East have been scheduled by one company, it was revealed, and there has probably been similar action by some other companies.

The prospective curtailment of imports is explained not only by the fight that independent companies have initiated against excessive imports but also by the fact that importing companies have been accumulating surplus stocks that could hurt them as well as others. Companies that import oils also have heavy stakes in the domestic industry, and they have declared repeatedly their agreement with independents that imports should be used only to supplement and not to displace domestic production.

During the past several months independent operators have expressed widespread and vociferous disapproval of increased imports. They have warned that incoming shipments should be promptly reduced, in view of recent cuts in domestic production allowables. They have appealed to Congress to take action restricting imports. Associations of independent operators have secured wide publicity in initiating a spirited fight against excessive imports.

The Independent Petroleum Association of America has issued a statement by its executive committee asserting that "an increasing flood of foreign oil is jeopardizing our national economy, our national security, and resulting in the unemployment of American labor."

Domestic producers are now more than able to supply every need of the American consumer, and output of domestic oil can be further increased, the statement continued. "But it will not be increased if this market is absorbed by foreign oil, thus depriving the independent oil producer of the funds necessary to discover and develop adequate reserves in the United States.

"Two World Wars have proved," said the statement, "that America cannot depend on foreign oil in an emergency. Foreign oil, thousands of miles away in troubled areas and under the insecure control of a combination of a few importing companies, is a slender thread on which to hang the security of the American people.

Importing companies "are endangering the national security," the statement declared, "in their rush to produce and sell their foreign oil in the markets of this country. Most of their foreign reserves are in the Middle East, less than two hours bombing time from Russia."

The Texas Independent Producers and Royalty Owners Association released a statement by its executive committee, warning that unless imports are voluntarily curtailed by importing companies, then there must be governmental regulation of imports.

Alf M. Landon, Republican Presidential candidate in 1936 and an independent oil operator in Kansas, wrote a letter to President Truman and declared that unless oil imports are reduced, there will be a recession in the American oil industry, and the national security will be jeopardized for lack of a strong domestic oil industry. He advocated closely regulated import quotas for foreign oil.

Governor Beauford H. Jester of Texas sent a letter to American oil importing companies, requesting that imports be reduced. He asserted that heavy imports had forced curtailment of domestic production, with the result that independent operators have less income with which to prove up new domestic reserves. In reply to the governor, Eugene Holman, president of Standard Oil Company (New Jersey) wrote that his company was reducing foreign as well as domestic production. He said the company's Venezuelan affiliate, Creole Petroleum Company, now has cut production 114,000 barrels daily. He also stated that in December his company took steps to cut imports of crude oil from the Middle East. In the final quarter of last year, he said, Jersey's imports from that source averaged 88,000 barrels a day, and they are scheduled at 50,000 daily in the first quarter of this year and tentatively at 33,000 daily in the second quarter.

"Adjustments of production to meet changing conditions are characteristic of the industry and inevitable," stated Holman. "Domestic consumption is expected to increase steadily at a normal rate. Domestic producers will be kept busy finding and developing enough oil to maintain this high level of production and to have a bit to spare for emergencies."

Markets Unsteady as Supply Exceeds Needs

ANXIETY OVER oil industry prices persisted in mid-February as current production and sharply increased stocks provided more supply than the markets were readily absorbing. Prices of distillate fuel oil, kerosine, residual fuel oil, and heavy crude oil has been reduced, and cutting of gasoline prices was threatened as stocks climbed repeatedly to new all-time peaks.

Because of the decline in residual fuel oil prices on the Pacific Coast, California heavy crudes were reduced 25 cents a barrel. On the East Coast there were reductions in residual fuel oil prices that were not compensated by lower costs of crude, and some refiners complained that because of the lower residual prices they were realizing 25 cents a barrel less for each barrel of crude processed.

On the East Coast about February 10 most oil companies and suppliers had reduced prices of home heating fuel oils by two-tenths to one-half cent a gallon and kerosine prices by one-tenth to six-tenths cent. The reductions were made because of large stocks that accumulated in January and February when the weather was warmer than normal for an extended **period.**

To some extent reductions in heating oil prices have been offset by small upward adjustments in gasoline prices.

Because of the weakened markets for refined products, crude oil prices were definitely jeopardized. It appeared that product prices would have to stabilize and show some improvement to assure maintenance of the prevailing crude prices.

It was being predicted in some quarters, therefore, that a general crude price reduction might occur before April 1.

Monthly News Analysis

ALLOWABLES CUT . . . TIDELANDS TITLE DEBATED . . . PRICE FIXING CHARGED

INDUSTRY EARNINGS MAY DECLINE . . . PIPE MILLS REPORT CANCELLATIONS

Surplus of Crude Forces New Cuts in Allowables

In spite of the lower production allowables of February, the surplus of crude grew more troublesome during the month, having been accentuated by relatively mild weather and slow demand for fuel oils.

To combat the surplus and keep new supplies from aggravating it, conservation agencies ordered further sharp reductions in crude production allowables for March. Allowable output in Texas was cut another 200,000 barrels per day as of March 1, after having been reduced about 25,000 daily February 1 and 200,000 daily January 1. Allowable production in Louisiana was reduced 20,000 barrels per day as of March 1, the first cut for the state in three years.

In February of this year U. S. crude production will average somewhat less than 5,400,000 barrels daily, or about the same as February of last year. In March, 1949, however, the nation's output apparently will average only around 5,150,000 or 5,175,000 barrels daily, a decrease of more than 4 percent from the 5,406,000 daily produced in March of 1948.

At the statewide hearing of the Texas Railroad Commission at Houston, on which the Texas March allowables were based, numerous witnesses described crude supplies on hand as abundant or excessive, and recommended cuts in allowable production. Representatives of several companies reported that their concerns were encountering distress conditions, with storage filled virtually to capacity. Especially acute, according to testimony, was the oversupply of crude in West Texas under February allowables.

Large Stocks Show Need For Reduced Operations

Continuing need of avoiding excessive crude production and refinery runs was indicated by February statistics on industry operations and stocks. Despite reduced rates of crude output and runs to stills, gasoline stocks reached new all time peaks several weeks in succession, and seasonal drafts on stocks of burning oils were less than normal because of January-February weather that was warmer than average in the areas of large consumption.

Stocks of finished and unfinished gasoline rose to 119,780,000 barrels in the week ended February 12, with a new all-time peak set for the third week in a row. This amount was 12,017,000 barrels or 11.2 percent more than the 107,763,000 barrels held a year previously. It has been estimated that gasoline demand in 1949 will be about 8 percent larger than in 1948. Production of gasoline amounted to 17,754,000 barrels during the week, compared with 15,429,000 barrels in the like week a year ago, although crude runs to stills were up only to 5,404,000 barrels daily from 5,378,000 daily in the comparable week last year.

Stocks of distillate fuel oil were lowered to 61,517,000 barrels from 64,175,000 in the week of February 12 but were then higher than a year previously by 25,322,000 barrels, or 70 percent. Demand for distillate fuel in 1949 is forecast at about 15 percent more than in 1948. Because of large stocks, production during the week was less than in the like week last year.

Kerosine stocks of 20,524,000 barrels February 12 were nearly double those of one year previously, although demand is expected to be only about 14 percent larger in 1949 than in 1948. Production has been held under last year's levels.

Residual fuel oil production also has been held under year-ago levels. Stocks showed virtually no change in the week of February 12 and at the end of the week totaled 82,340,000 barrels. That was 32,302,000 barrels or 64.6 percent more than the 50,038,000 barrels held a year previously. Residual demand is expected to be about the same in 1949 as in 1948.

In the week ended February 12, U. S. crude oil and lease condensate production averaged 5,386,750 barrels daily. In the month of February, 1948, the corresponding daily average production was 5,353,000 barrels.

Title to Tidelands Debated In Court and in Congress

Congressional hearings on various pending tidelands ownership bills will be facilitated as a result of the organization of an Off-Shore Operators' Committee by companies engaged in tidelands development.

Decision to organize the committee was based on desirability of a forum for discussing common operating problems and on the need of a central organization for compiling and correlating information pertaining to off-shore development for presentation to Congress.

The committee will be called upon also to select operators, engineers, and other witnesses to testify at the congressional hearings.

The National Petroleum Council, representing the industry and established by the Interior Department to advise it on petroleum matters, has unanimously adopted a statement urging state rather than federal control of the tidelands.

Bills to recognize state title to submerged lands, identical with H.R. 5992, passed by the House last year, have been introduced in the House in the new Congress. Congressmen from Texas, Louisiana, California, and other coastal states have declared they will vigorously seek passage of legislation denying federal claims to the tidelands and granting clear title to the states.

At request of Justice Department, Representative Celler of New York introduced the administration bill on tidelands. It would enact into law the ruling of the Supreme Court in 1947 that the federal government has paramount interest over submerged lands off the California coast.

In his message to Congress on the state of the Union, President Truman reasserted that tidelands ownership "must remain vested in the federal government." He asked for a "program for planned use" of the reserves. He also declared he would veto again, as he did in 1946, a bill to quitclaim the tidelands to the states. Those supporting state claims believe that they can secure passage of legislation by Congress to

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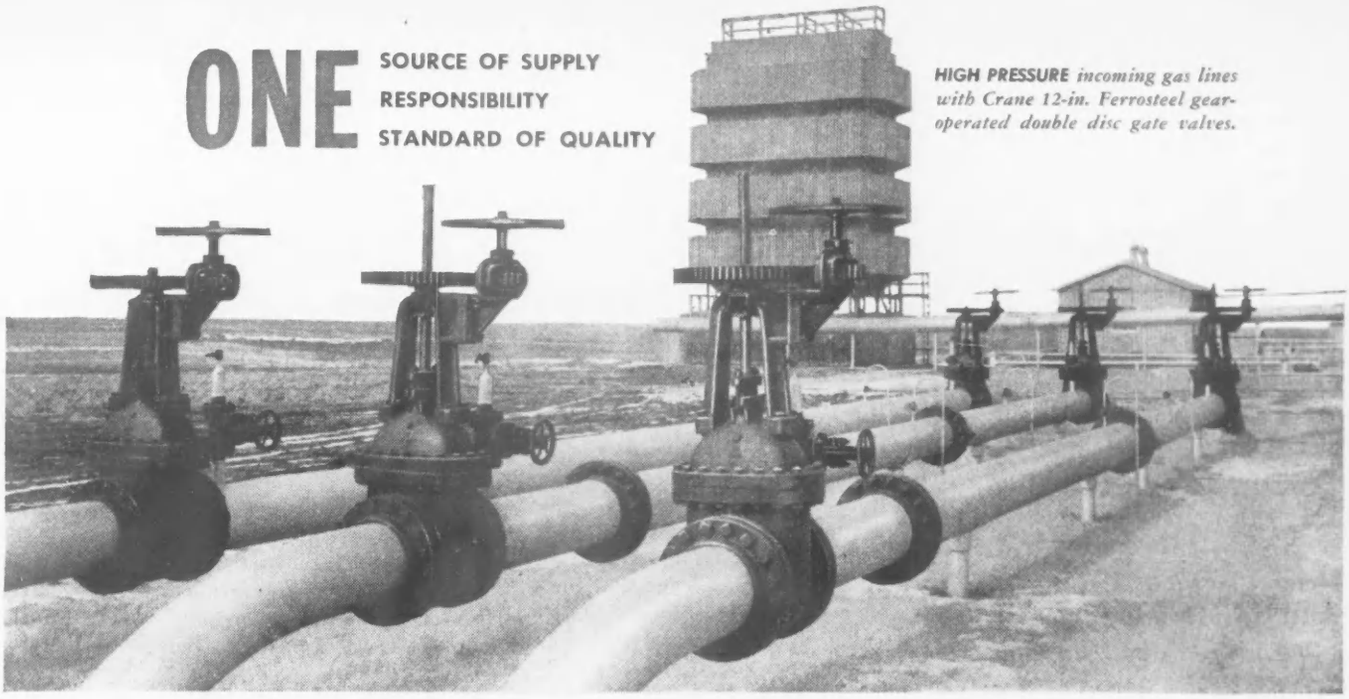

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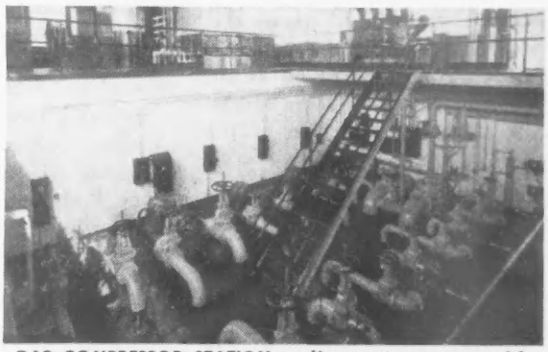

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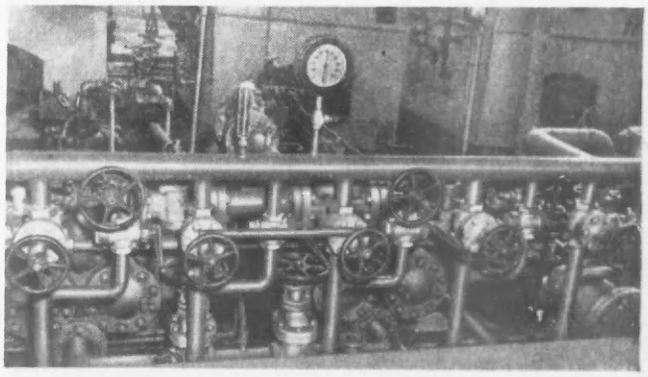

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give title to the states. But some doubt ability to get two-thirds majority needed to override a presidential veto.

U. S. Supreme Court will hear oral arguments, probably in early April, before deciding whether it will accept for hearing the tidelands suits of Attorney General Tom Clark against Texas and Louisiana. Without first going to lower courts in usual manner, Clark has gone direct to highest court and asked it to hear the cases. Attorneys for Texas and Louisiana are preparing the arguments with which they will object to the taking of jurisdiction in the cases by the Supreme Court. In challenging this jurisdiction, they contend that such suits should be filed in federal district courts in the states affected.

Price Fixing of Crude Oil And Gasoline Is Charged

The ten major oil companies charged with violating Texas anti-trust laws in pricing of gasoline and crude oil may be expected to carry their defense against the charges through the higher courts if necessary.

Typical of early comments on the cases from among oil companies involved was that of L. T. Barrow, chairman of the board of Humble Oil & Refining Company. Questioned about the cases before having seen the state's petition, he said, "We know of no violation of the anti-trust laws by the Humble company and can conceive of no basis for making it a defendant in the suit."

Suits were filed February 21 in 98th District Court at Austin by Attorney General Price Daniel, and he said he would seek early trial of the cases before Judge Charles O. Betts.

The 10 companies charged with illegally fixing and maintaining gasoline tank wagon prices were: Arkansas Fuel Oil Company, Cities Service Oil Company, Continental Oil Company, Gulf Oil Corporation, Humble Oil & Refining Company, Magnolia Petroleum Company, Standard Oil Company of Texas, Sinclair Refining Company, The Texas Company, and Phillips Petroleum Company.

Eight of those ten companies, including all except Phillips and Sinclair, were charged in another complaint, alleging collusion to prevent a general increase in prices paid to producers for crude oil. Phillips and Sinclair posted increases of 35 cents a barrel on crude prices in the latter part of 1948, but when other purchasers declined to meet the raise, they later rescinded their higher postings. The suit filed by the Texas attorney general alleged that the other eight companies combined efforts to hold down the crude price "for the purpose of maintaining . . . abnormally large profits." Such profits were made possible, the petition said, by the "wide spread between crude oil prices and the selling price of refined gasoline."

In the case involving gasoline prices, the ten companies were charged with eliminating competition among themselves by fixing a "uniform price . . . at every city which they serve" in Texas.

The attorney general asked for injunctions and fines ranging from $50 to $1500 per day for the period in which the violations allegedly occurred —since July, 1946, when price control by O.P.A. was removed from oils.

Refiners and marketers were alleged to have "combined their capital, skill, and acts" to increase, fix, and maintain uniform prices on gasoline delivered for sale to Texas filling stations since July, 1946. The suit alleged that the six gasoline price increases since O.P.A. control was lifted had been almost simultaneous as well as identical.

The defendants may be expected to show that the gasoline price increases were made in compensation for advances in prices paid by refiners for crude oil. Mid-Continent crude prices were increased five different times in the latter half of 1946 and the year 1947, and in 1948 there was reported to be some paying of premiums for crude by some refiners, although the fall raises by Phillips and Sinclair did not become general and later were rescinded.

Similarly, defendants in the suit charging collusion on crude prices in 1948 may be expected to present evidence that increased supplies of crude oil prevented general adoption of the higher crude prices initiated by Phillips in September, 1948. At that time statements were given out by officials of several companies, saying their postings would not be increased because adequate supplies of crude for their requirements were available without paying higher prices.

Oil Company Earnings May Not Hold at 1948 Levels

Although the petroleum industry will experience in 1949 another year of record operations, its aggregate earnings may show some decline from the all-time peak reached in 1948, it is predicted in an analysis by Carl H. Pforzheimer & Company, New York stock brokers. Increased production and ample inventories have eased the upward pressure on oil prices, says the report, and prospects are that lower refinery realizations will result and that profit margins generally will be narrowed by return of a more competitive situation.

Offsetting this to some extent, however, states the report, will be the elimination of many of the uneconomic practices to which the industry resorted to supply all demands during the period of short supply, such as premiums above posted prices of crude oil and expensive railroad transportation and cross hauling of large quantities of crude oil and refined products. Any change in corporate income tax rates also will have a bearing on net earnings.

Oil industry earnings in 1948 are estimated by the Pforzheimer report to have increased approximately 60 percent over 1947 profits, in reflection of increased sales and higher average prices of crude oil and refined products during the year. Increased earnings were used in large measure for financing expansion, although they were used partly to increase dividends to stockholders. The report estimated that oil companies distributed on the average only 25 percent of their earnings last year, compared with 35 percent in 1947 and 45 percent in 1946.

Bill Would Except Gas Well Owners from FPC Control

Two bills, seeking to amend the Natural Gas Act, have been introduced in Congress and referred to the House commerce committee. A bill by Representative Lyle, Democrat, Corpus Christi Texas, H. R. 79, would make certain that independent producers and gatherers are exempt from control by Federal Power Commission. The bill by Representative Dolliver, Republican, Iowa, H. R. 982, is the same one he offered in the previous Congress and seeks to provide for the establishment of a policy for the administration of the Natural Gas Act.

Order to Stop Gas Flaring Is Upheld by Texas Court

Power of the Texas Railroad Commission to prevent the flaring of casinghead gas produced along with oil gained strong support when the Texas Supreme Court, February 16, upheld the commission's order against flaring gas in the Heyser oil field of Calhoun and Victoria counties.

By seven to two decision the court dissolved an injunction granted by Judge Charles O. Betts of 98th District Court, restraining the commission from enforcing its order of November 22, 1948, to shut in the field until operators stop wastful flaring of gas.

The court pointed out, however, that its decision applied only to the Heyser field case and did not prejudice issues that may be involved in other fields. The court has held that each oil field presents a separate problem.

Attorney General Price Daniel of

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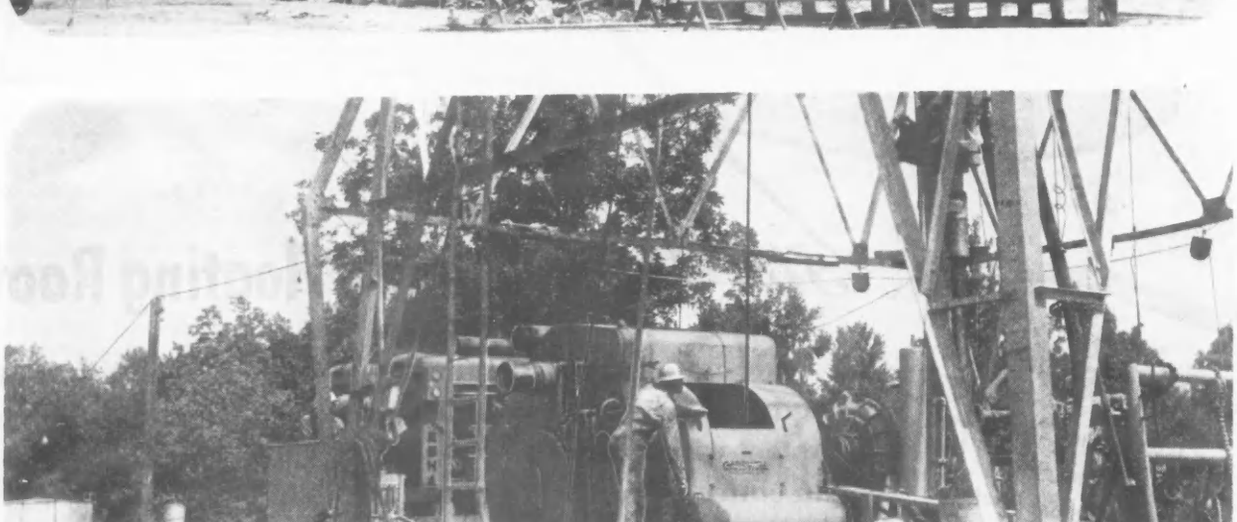

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Texas, gratified by the decision, said he would proceed to trial in 15 other similar cases now pending, although he is said to have considered the Heyser case his strongest. Operators in those 15 other fields similarly obtained injunctions, and operators in another 26 fields presented testimony before the Railroad Commission January 25 to show cause why they should not be required to shut in oil production until gas-conservation measures were put into effect.

Operators contended that the Heyser shutdown order was not fair and reasonable and properly supported by evidence. The court ruled that the order was "reasonably supported by evidence and that it is valid. We further hold that the order is not discriminatory, unreasonable, or arbitrary, and it is affirmed."

After the decision, William J. Murray, Jr., chairman of the Texas Railroad Commission, expressed belief that the result would be to further stimulate and expedite an immense conservation program to utilize flare gas, which has been in progress since the end of the war.

Pipe Cancellation Orders Promise More Steel Goods

First cancellations of orders in oil country goods have been reported by several pipe mills. The cancellations are scattered and few but may point to the adjustment that has long been awaited in the tubular goods bottleneck. Casing, drill pipe and tubing are among the items involved in the cancellations.

Demand, however, still continues high for large-diameter pipe, for both oil and gas. In fact, several new gas lines are being mapped in the expectation that large-size pipe will become more available shortly. About the beginning of February the first trainload of 30-inch pipe was shipped from the Los Angeles plant of Consolidated Steel Corporation so work could begin on Transcontinental Gas Pipeline Corporation's projected line from Texas to New York. In all, 470,000 tons of pipe will be required for this one job.

Republic Steel's new Gadsden, Ala., plant has reached its capacity of 100,000 tons per year ahead of schedule. The gray market in steel sheets has become less active; offers of hot-rolled sheets as low as 7 cents a pound have gone without takers, and price-cutting has been resorted to in the Pittsburgh area to increase business volume.

Among gas industry customers which have received pipe shipments during the last month are Southern Natural Gas, Tennessee Gas Transmission, El Paso Natural Gas, and Northern Natural Gas.

Increase of Gasoline Tax Would Not Provide Roads

Although 16 state legislatures now have bills proposing gasoline tax rate increases, the additional revenues they would bring in would largely lie idle or be diverted to non-highway uses. Road building programs are held back not by shortages of funds but by continuing shortages of materials, equipment, and trained engineers. This situation has been proved by recent experiences in Colorado, Maryland, and Kentucky, where gasoline tax increases have raised more funds but failed to provide additional roads because of the mentioned shortages.

New Motor Vehicles Boost Consumption of Gasoline

Foreshadowing large consumption of gasoline, figures of Automobile Manufacturers Association show factory sales of 5,285,425 motor vehicles in 1948, highest on record except sales of 5,358,420 units in 1929. The 1948 total was 10 percent more than the 4,797,922 units sold in 1947. Exports of 436,217 units in 1948 were 15 percent under those of 512,333 units in 1947.

Passenger car sales in 1948 totaled 3,909,270, compared with 3,558,178 in 1947. Factory sales of trucks in 1948 were an all-time record of 1,363,856 units, compared with 1,220,634 in 1947. Motor bus sales of 12,299 in 1948 were off from the 19,110 of 1947.

Greater Oil Use and Keen Competition Are Foreseen

After having eliminated oil shortages by means of a huge expansion program, the oil industry henceforth will keep markets well supplied, and typical American competition will assure reasonable prices for petroleum products. But the markets for gasoline, diesel oil, heating oil, and other products will continue to expand steadily, with the result that the industry should continue to show favorable results in its operations.

This outlook for the industry was forecast by R. M. Bartlett, vice president of Gulf Oil Corporation, in a recent address.

In 1948 alone, said Bartlett, the industry's investment in necessary plant and equipment reached the staggering total of $2½ billion. The heavy capital investments have used up the lion's share of oil company earnings. They have been necessary, he said, "because all signs point to steadily increasing oil consumption. The population is increasing, more cars are being purchased in all income brackets, and the average mileage driven per car is rising. Meanwhile, growth of petroleum use on the farm, in industry, and in the home continues at a phenomenal rate."

In regard to gasoline sales, Bartlett said, "We should go into the summer in good shape for an old-fashioned competitive battle." He pointed out that on the East Coast gasoline stocks were 11 percent above a year previously, while demand for gasoline is expected to increase by only 6½ percent in 1949 over 1948.

In the heavy fuel oil field, said Bartlett, prices are down, stocks are up, and the industry is looking for new sales outlets.

"The industry's program of modernization and improvement has succeeded so well," he stated, "that we are again able to compete with coal. The battle of the two giant energy sources, oil and coal, is on again in full force."

With reference to domestic heating oils, Bartlett cited that 45 percent of American families express preference for central oil heat but only 20 percent so far have oil furnaces installed.

"There are another 5,000,000 families," he continued, "who want the convenience of oil heating and are waiting to be convinced they should go ahead." However, he cautioned, this business can be secured only by aggressive, prewar type salesmanship.

Oil Burner Installations Reduced Sharply in 1948

While there has been an oversupply of heating and burning oils this winter, the industry feared a year ago that there would be a shortage. It therefore discouraged installation of new oil burners in 1948. In its efforts it was very successful.

Oil burner shipments of 419,907 units in 1948 showed a decrease of 62 percent from the 1,127,352 units shipped in 1947, the Census Bureau reported. Shipments of residential burners dropped to 392,864 units in 1948 from 1,078,576 in 1947.

The report showed decreases in 1948 in shipments of all heating and cooking equipment requiring oil industry fuels except installations using liquefied petroleum gas. Shipments of liquefied petroleum gas ranges totaled 622,850 in 1948, compared with 563,861 in 1947.

Shipments of oil-fired warm air furnaces were down to 179,623 units in 1948 from 290,114 in 1947. Shipments of kerosine, gasoline, and fuel oil heating stoves declined to 1,939,693 in 1948 from 2,412,216 in 1947. Shipments of kerosine, gasoline, and fuel oil cooking stoves and ranges decreased to 466,777 in 1948 from 599,579 in 1947.

Looking Ahead

• CONSENSUS OF numerous analysts is that 1949 may not be quite as prosperous generally as 1948, the biggest year in peacetime history, but that 1949 is likely to be, on the whole, a good year. In 1948 physical production was 3 percent above 1947, personal incomes were up 8½ percent, and consumer expenditures were up 7 percent. In 1949 supply is catching up with demand at prevailing prices. But prices are softening and may decline somewhat more, and at lower prices, demand is stimulated.

• FAIR BALANCE of steel supply with demand is hoped for by middle of this year. Steel production has been setting new records. In past several weeks it has been at rate of more than 97 million tons per year.

• UNCERTAINTY of business outlook is expected to continue for next few months. Price declines have been limited mainly to farm products and foods. But increased supplies have softened prices of some other goods, including petroleum products. Unemployment has been increasing in some lines and business failures are rising, but heavy goods industries generally continue near-capacity operations.

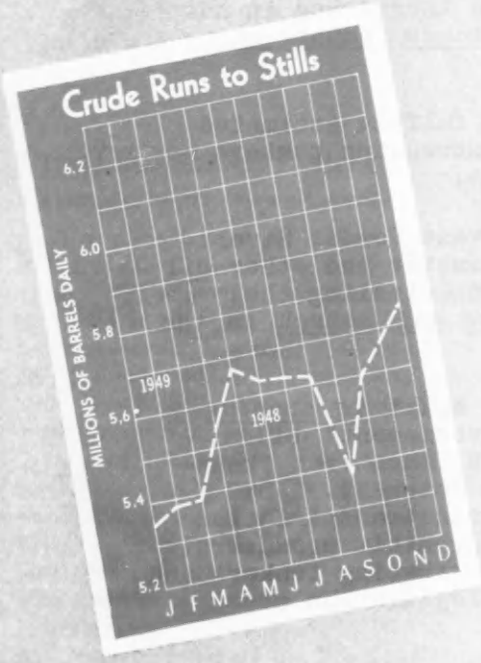
• MORE MILEAGE on vacation trips in 1949 will help fulfill estimated rise of about 8 percent in gasoline consumption. Increasing numbers of new cars encourage more driving and longer trips.

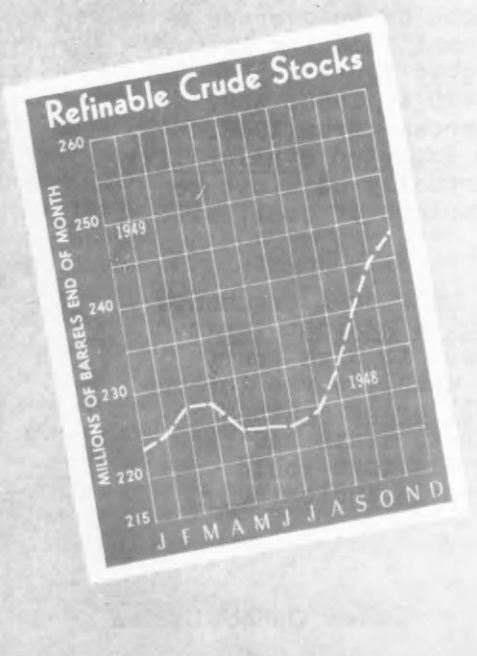
• AN ERA of deep basin drilling is opening in the vast Powder River Basin of northeastern Wyoming. Seismograph, magnetometer and other oil exploratory crews are reported moving into the towns circling the Basin, ready for the jump-off of the most intensive oil search in the history of this big sheep grazing region.

• ANOTHER ATTEMPT to reduce the oil industry "to size" is shaping up in Congress with the introduction of three "divorcement" bills. S-571 would prohibit interstate common carrier pipe lines from transporting commodities in which such carriers have an interest. S-572 would divorce the business of producing, refining and transportation from marketing of petroleum products. S-573 would prohibit producers, refiners and marketers of petroleum products from operating tankers and barges. Prospects for passage of this restrictive legislation are remote.

• NATURAL GAS sales by public utilities will increase by an average of 11 percent annually in next several years. National Security Resources Board placed these sales at 2817 billion cubic feet in 1948 and estimated increases to 3213 billion in 1949, 3490 in 1950, 3697 billion in 1951, and 3903 billion in 1952, up 43 percent from 1948. These estimates were described as essentially "the expected availability of gas," as potential consumer demand will have virtually no limit so long as gas prices remain relatively cheaper than prices of coal, oil, and other fuels.

• PROBABLY IN early April U. S. Supreme Court will hear oral arguments before deciding whether it will accept tidelands suits against Texas and Louisiana. Attorney General Tom Clark went direct to high court and asked it to hear these cases instead of taking usual course through lower courts. Attorneys for Texas and Louisiana will argue against Supreme Court jurisidction. Meanwhile supporters of both state and federal claims to tidelands are backing bills in Congress that would recognize their claims by law. Stalemate in Congress is indicated, with some kind of compromise a possibility.





Producing and Refining Operations

THERE was considerable slackening in the industry's producing and refining operations during January, as the nation's storage facilities began to fill with stocks of crude and refined products.

Above-ground supplies of refinable crude were at the highest level since early in the war, and by the end of January gasoline stocks had climbed to the highest peak in history. Other principal refined products, kerosine, distillate fuel oil and residual fuels, were in good supply, and while not at all-time peaks, were considerably higher than a year earlier.

Crude output from the nation's fields dropped from an all-time high of 5,680,000 barrels daily in December to 5,489,000 barrels daily in January. That decrease amounted to 191,000 barrels per day. Despite January's production drop, the month still topped output of a year ago by 206,000 barrels daily and that of two years back by 818,000 barrels a day.

Texas accounted for most of the production drop, declining from 2,536,400 barrels a day in December to 2,364,100 daily in January. That drop accounted for more than 172,000 of the nation's 191,000-barrel decrease. California, the second largest producing state, contributed materially to the decline by lowering its daily output more than 11,000 barrels to 949,000 a day.

Refiners lowered their rates of operation during the month, running 5,623,000 barrels daily to their stills. That amounted to a decrease of 120,000 barrels a day from December's all-time high of 5,743,000 barrels daily. January's runs to stills were still 275,000 barrels daily greater than those of January, 1948, and 884,000 a day more than in the same month two years ago. Domestic production during the month failed by 134,000

Crude Oil and Refined Products Trends

(THOUSANDS OF BARRELS)

MONTH	CRUDE OIL			GASOLINE		DISTILLATE FUEL		RESIDUAL FUEL	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month
1946:									
January	4,625	4,520	223,442	1,914	102,394	787	28,990	1,224	34,573
February	4,719	4,651	227,220	1,884	104,836	823	25,511	1,243	34,008
March	4,414	4,661	221,400	1,900	104,161	815	29,922	1,213	32,995
April	4,673	4,663	222,480	1,943	98,744	773	32,064	1,247	35,206
May	4,785	4,794	221,592	2,016	93,960	753	33,385	1,220	38,932
June	4,896	4,836	223,140	2,055	91,971	777	38,824	1,219	41,492
July	4,922	4,856	224,351	2,102	87,778	793	46,439	1,163	45,446
August	4,836	4,856	224,157	2,189	86,745	765	54,068	1,159	48,186
September	4,790	4,839	222,417	2,143	87,021	796	62,019	1,150	54,012
October	4,785	4,736	222,177	2,117	85,952	788	76,780	1,090	55,580
November	4,823	4,684	226,453	2,162	88,587	791	68,145	1,101	52,735
December	4,725	4,789	224,473	2,168	92,742	805	59,912	1,159	47,094
1947:									
January	4,671	4,739	223,848	2,078	99,623	778	48,197	1,174	41,550
February	4,810	4,820	225,121	2,089	103,672	777	36,901	1,228	48,480
March	4,908	4,843	228,981	2,076	105,679	825	31,423	1,222	37,403
April	4,974	4,707	235,710	2,037	101,724	764	30,268	1,148	36,455
May	5,033	4,947	237,768	2,128	95,209	805	34,279	1,204	39,992
June	5,099	5,120	237,278	2,258	89,774	807	39,676	1,233	43,515
July	5,137	5,221	230,974	2,302	86,003	847	46,444	1,244	47,600
August	5,173	5,260	228,523	2,383	85,849	869	54,707	1,245	51,334
September	5,251	5,236	225,258	2,375	84,360	911	59,764	1,237	52,578
October	5,320	5,253	226,666	2,371	82,584	938	63,252	1,260	52,502
November	5,291	5,291	225,462	2,332	87,551	942	61,334	1,245	52,455
December	5,337	5,350	224,929	2,347	92,303	992	51,081	1,282	47,091
1948:									
January	5,283	5,348	223,430	2,328	102,167	1,082	41,036	1,278	44,636
February	5,353	5,380	224,880	2,264	110,999	1,127	34,590	1,295	43,156
March	5,406	5,387	227,408	2,252	111,949	1,050	32,214	1,307	41,945
April	5,484	5,540	227,278	2,396	109,289	978	34,514	1,303	43,301
May	5,502	5,668	223,820	2,486	108,552	992	40,781	1,314	48,518
June	5,544	5,632	223,481	2,529	104,518	998	48,352	1,280	52,465
July	5,522	5,631	223,124	2,494	98,839	994	58,725	1,264	58,431
August	5,577	5,621	224,211	2,532	95,445	1,038	68,818	1,248	64,096
September	5,435	5,376	228,401	2,416	90,518	961	76,320	1,154	68,005
October	5,632	5,594	234,615	2,490	92,426	1,069	82,920	1,268	72,363
November	5,675	5,672	240,083	2,551	95,589	1,081	83,909	1,277	77,033
December	5,680	5,743	243,017	2,614	104,063	1,098	77,151	1,295	76,549
1949:									
January	5,489	5,623	245,744	2,567	115,598	1,103	66,502	1,255	74,435
January, 1949: Changes:									
In Month	—191	—120	+2,727	—47	+11,535	+5	—10,649	—40	—2,114
In One Year	+206	+275	+22,314	+239	+13,431	+21	+25,446	—23	+20,799
In Two Years	+818	+884	+21,896	+489	+15,975	+325	+18,305	+81	+32,885

Slacken As Stocks Hit High Level

barrels a day of providing the requirements of refineries. However, with crude imports now at a high level this difference was easily made up and still allowed almost 3 million barrels to be added to crude stocks.

Refinable crude stocks amounted to 245,744,000 barrels at the end of January to show a gain of 2,727,000 barrels since the end of the year. These stocks were 22,314,000 barrels more than were in storage a year before and 21,896,000 barrels more than were held two years ago. Not since September, 1942, have crude stocks reached the 246 million mark, and it is plain that the only reason crude stocks are building at this time is because of extra heavy importations, for several months have passed since domestic oil production equalled that which was refined.

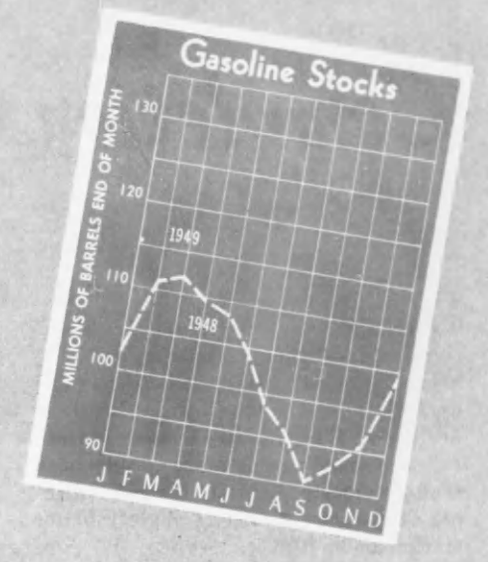
Despite the refining cutback and a resulting small decrease in gasoline production, stocks of this product climbed to an all-time peak of 115,598,000 barrels by the end of January. By the middle of February, these stocks had risen to 122½ million barrels, which is by far the greatest amount ever held by the industry. Prior to January, the highest gasoline stocks had ever been was slightly more than 113 million barrels. That was in April, 1948. Converting current gasoline stocks to gallons it is found they total well over 5 billion gallons, which should assure motorists and other users of ample supplies this coming summer.

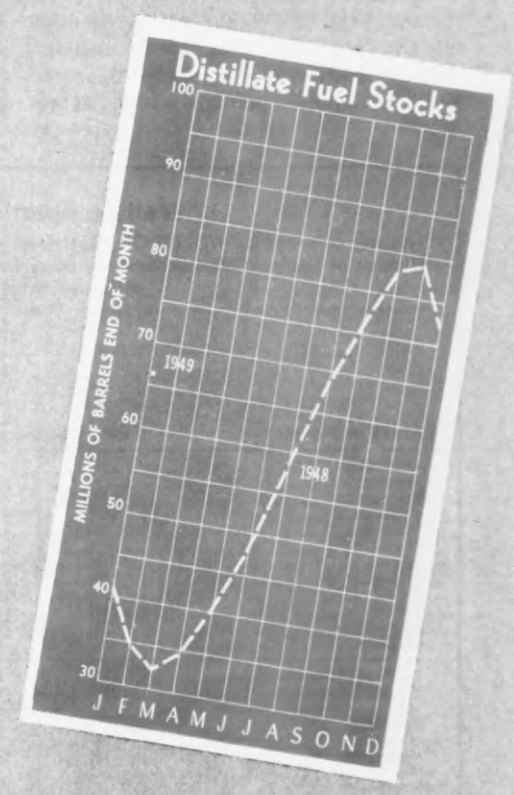
Winter weather continued to lower distillate fuel oil stocks for the second straight months. A decrease of 10,649,000 barrels during January dropped inventories to 66,502,000 barrels at the month's end, which were still 25,466,000 barrels more than were in tanks a year ago. Production of these light domestic fuels during the month remained practically the same as in December, with an increase of only 5000 barrels a day. January's distillate fuel output averaged 1,103,000 barrels daily, an increase of 21,000 a day over production a year ago.

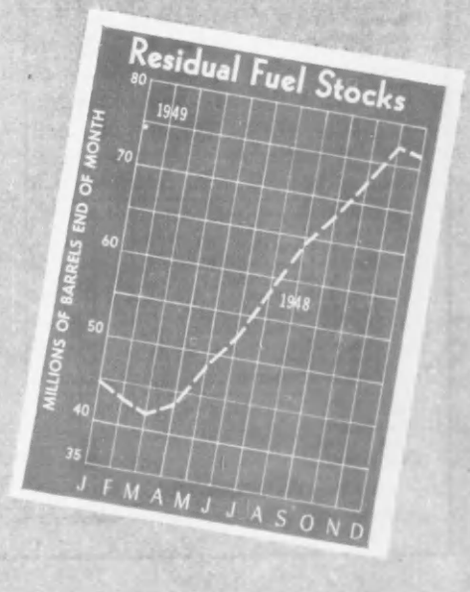
State Crude Oil Production

(THOUSANDS OF BARRELS)

STATE or DISTRICT	DAILY AVERAGE PRODUCTION				TOTAL PRODUCTION		
	Jan., 1949	Dec., 1948	Jan., 1948	% Diff. '48-'49	Jan., 1949	Jan., 1948	% Diff. '48-'49
Alabama	1.3	1.2	1.3	.....	39	39	.....
Arkansas	88.7	86.3	83.3	+ 6.4	2,748	2,583	+ 6.4
California	949.1	960.3	931.0	+ 2.0	29,423	28,860	+ 2.0
Colorado	65.2	63.3	46.2	+ 41.0	2,020	1,433	+ 41.0
Florida	1.3	0.9	0.8	+ 62.5	39	24	+ 62.5
Illinois	181.2	179.4	172.1	+ 5.3	5,618	5,335	+ 5.3
Indiana	24.2	24.0	14.0	+ 72.6	749	434	+ 72.6
Kansas	293.2	301.5	289.2	+ 1.4	9,090	8,966	+ 1.4
Kentucky	24.0	23.9	23.5	+ 2.3	745	728	+ 2.3
Louisiana	520.4	511.4	469.7	+ 10.8	16,131	14,560	+ 10.8
North Louisiana	121.0	118.1	110.4	+ 9.6	3,750	3,422	+ 9.6
South Louisiana	399.4	393.3	359.3	+ 11.2	12,381	11,138	+ 11.2
Michigan	46.9	45.5	45.2	+ 3.8	1,454	1,401	+ 3.8
Mississippi	119.5	130.2	113.7	+ 5.0	3,704	3,526	+ 5.0
Missouri	0.2	0.2	0.2	.....	5	5	.....
Montana	25.3	26.1	24.2	+ 4.5	784	750	+ 4.5
Nebraska	0.3	0.3	0.5	— 47.1	9	17	— 47.1
New Mexico	134.7	134.4	123.9	+ 8.8	4,176	3,840	+ 8.8
New York	13.9	14.0	12.1	+ 14.7	430	375	+ 14.7
Ohio	8.8	8.8	7.9	+ 12.7	275	244	+ 12.7
Oklahoma	446.7	443.2	390.9	+ 14.3	13,848	12,117	+ 14.3
Pennsylvania	31.5	31.8	32.9	— 4.2	978	1,021	— 4.2
Tennessee	.....	.....	.....	.....	1	1	.....
Texas	2,364.0	2,536.4	2,352.7	+ 0.5	73,284	72,933	+ 0.5
Dist. 1—South Central	27.1	28.0	25.6	+ 5.9	839	792	+ 5.9
Dist. 2—Middle Gulf	164.8	181.1	168.1	— 1.9	5,110	5,211	— 1.9
Dist. 3—Upper Gulf	468.9	516.5	496.3	— 5.5	14,535	15,384	— 5.5
Dist. 4—Lower Gulf-S.W.	228.9	252.7	255.6	— 10.4	7,097	7,925	— 10.4
Dist. 5—East Central	46.5	51.9	44.1	+ 5.6	1,442	1,366	+ 5.6
Dist. 6—Northeast	410.3	418.6	415.3	+ 1.2	12,721	12,874	+ 1.2
Dist. 7-B—North Central	62.8	62.1	42.9	+ 46.3	1,946	1,330	+ 46.3
Dist. 7-C—West Central	48.5	50.3	42.8	+ 13.5	1,505	1,326	+ 13.5
Dist. 8—West	678.0	741.7	658.7	+ 2.9	21,017	20,419	+ 2.9
Dist. 9—North	138.9	144.3	142.4	— 2.4	4,305	4,413	— 2.4
Dist. 10—Panhandle	89.3	89.8	92.0	— 3.0	2,767	2,853	— 3.0
Utah	0.2	0.1	.....	.....	5	.....	.....
Virginia	0.1	0.1	.....	.....	1	1	.....
West Virginia	7.7	7.3	6.8	+ 13.8	239	210	+ 13.8
Wyoming	141.2	149.5	141.2	.....	4,377	4,378	.....
Total United States	5,489.6	5,680.1	5,283.3	+ 3.9	170,172	163,781	+ 3.9







Completions In Seasonal Decline

DRILLING activity in January eased considerably when compared with the rapid tempo of the previous month's operations. After the record-breaking drilling of 1948, January's normal slackening seemed even more pronounced than previously. Actually the year's drilling campaign got off to a slightly better start than in 1948.

Each year, the first several months see relatively slow progress in drilling. This is mainly caused by severe weather. Some operators even go so far as to shut down operations when the winter weather starts, with no intentions of opening up until after its passing. Many operators use the heaviest weather period for overhauling their equipment in order to have it ready for the start of favorable drilling weather.

Just how the current year's drilling will compare with last year's remains to be seen. WORLD OIL has predicted that it will result in completion of more than 39,500 wells, which would be a new all-time record (Page 96, February 15, 1949). It must be remembered that 1948 lagged behind its previous year for the first several months, and then got under way to finish far ahead of any year in history in number of wells drilled.

Well completions totaled 2961 in January to show a drop of 554 wells from December's results. However, only 2947 were finaled in January of last year. This was only a small rise, amounting to only one-half of 1 percent, but still it showed a favorable comparison with a comparable period.

Well Completions in the United States During January, 1949

(Figures compiled by WORLD OIL Staff from private reports and other sources as follows: Illinois from Illinois Geological Survey: Indiana Division of Geology: Missouri from Missouri Geological Survey: Tennessee from Tennessee Division of Geology: Bradford, Kane-Clarendon and Allegany fields of Pennsylvania and New York from the Producers Monthly.)

STATE or DISTRICT	MONTHLY COMPLETIONS—Details for January, 1949									Total Completions			Percent Difference From Year Ago	Total Footage January, 1949	Rigs in Operation (Drilling, Rigging Up and Shut Down)		
	NEW WELLS								Total Drilled Deeper								
	Oil	Dist.	Gas	Dry	Water Input	Gas Input	Water Disposal	Total New		Jan., 1949	Dec., 1948	Jan., 1948			Jan. 31, 1949	Dec. 31, 1948	Jan. 31, 1948
Alabama				1				1		1	2	1	.....	15,668	6	4	1
Arizona															8	8	1
Arkansas	10			6				16		16	24	31	— 48.4	79,630	30	37	35
California	157		1	47				205	2	207	204	220	— 5.9	823,516	295	259	293
Colorado	1			2				3		3	20	27	— 88.9	13,004	23	25	59
Florida				2				2		2	3	3	— 33.3	9,316	4	5	4
Illinois	78		1	69				148	1	149	235	146	+ 2.1	389,463	227	263	203
Indiana	36			39				75		75	104	77	— 2.6	149,493	122	119	113
Iowa																	
Kansas	115		15	68			1	199		199	336	208	— 4.3	670,140	269	320	321
Kentucky	35		23	19				77		77	58	65	+ 18.5	133,030	72	76	70
Louisiana	107	11	13	37				168		168	175	145	+ 15.9	1,021,206	197	205	196
North Louisiana	55	5	10	15				85		85	114	78	+ 9.0	301,339	61	61	60
South Louisiana	52	6	3	22				83		83	61	67	+ 23.9	719,867	136	144	136
Maryland												1	—100.0				
Michigan	28		3	43				74		74	90	57	+ 29.8	172,968	104	109	96
Mississippi	13			8				21		21	30	36	— 41.7	143,511	35	37	52
Missouri			1					1		1	2		.....	516	9	10	5
Montana	9		1	8				18		18	16	28	— 35.7	57,190	52	53	62
Nebraska																	1
Nevada															1	1	1
New Mexico	29		4	6				39	1	40	69	56	— 28.6	199,736	87	104	108
New York	65			1	43			109		109	144	145	— 24.8	151,753	148	179	184
North Carolina																	
North Dakota															1	1	
Ohio	34		31	37				102	2	104	78	91	+ 14.3	251,665	164	203	211
Oklahoma	190		12	116	1		1	320	4	324	329	355	— 8.7	1,303,312	474	501	541
Pennsylvania	101		37	14	81	16		249	3	252	242	266	— 5.3	466,313	344	391	368
South Dakota															2	2	1
Tennessee	1			2				3		3	5	3	.....	3,458	10	9	19
Texas	559	13	78	325	1		3	989	19	1,008	1,229	871	+ 15.7	4,317,019	1,360	1,492	1,290
Dist. 1—South Central	20			27			1	48	1	49	52	40	+ 22.5	154,436	42	39	50
Dist. 2—Middle Gulf	15	3	7	14				39		39	59	71	— 45.1	243,986	50	46	55
Dist. 3—Upper Gulf	68	4	5	46				123		123	101	77	+ 59.7	778,819	143	135	113
Dist. 4—Lower Gulf-S.W.	60	4	3	42				109	3	112	156	104	+ 7.7	592,356	127	122	116
Dist. 5—East Central	15	1		9				25	1	26	29	16	+ 62.5	104,615	33	28	33
Dist. 6—Northeast	23	1	5	8			1	38	1	39	45	39	.....	192,986	35	41	50
Dist. 7-B—North Central	60		3	79				142		142	142	93	+ 52.7	432,370	199	235	124
Dist. 7-C—West Central	16			4				20	3	23	46	28	— 17.9	91,316	74	80	62
Dist. 8—West	140		4	22	1			167	9	176	286	199	— 11.6	904,614	404	449	443
Dist. 9—North	80			76			1	157	1	158	248	159	— 0.6	411,996	125	147	115
Dist. 10—Panhandle	62		51	8				121		121	65	45	+168.9	409,525	134	170	129
Utah				1				1		1	2	2	— 50.0	6,150	13	11	14
Washington											1						1
West Virginia	12		29	13				54	1	55	75	77	— 28.6	160,486	336	362	365
Wyoming	38		1	15				54		54	42	36	+ 50.0	242,653	113	123	84
Total United States	1,618	24	250	889	126	16	5	2,928	33	2,961	3,515	2,947	+ 0.5	10,781,196	4,512	4,909	4,699

THE dispute over crude imports into the U. S. promises to be a bitter battle within the industry this year, and already is having repercussions in Congress. The question has divided the American petroleum industry into opposing sides just one year after the nation became for the first time since 1922 a net importer rather than a net exporter of oil.

Petroleum imports have increased sharply of late, reaching an all-time high of about 600,000 barrels a day of crude and products by the end of 1948. Further, the rate of increase rose steadily during all of last year, as the following table shows:

1948	Imports of Crude and Products (Barrels daily)
August	499,000
September	528,000
October	530,000
November	583,000
December (est.)	600,000

Table 1 shows the history of petroleum exports and imports. Exports averaged 447,000 barrels a day in the 1935-1939 period, an excess of exports over imports of 294,000 barrels a day. But in the closing months of 1948, exports were 340,000 barrels a day, or 217,000 barrels a day below imports. These figures do not reflect the large volumes of oil being supplied U. S. armed forces from foreign sources.

Table 2 shows petroleum imports by quarters during 1948, broken down by products, countries of origin and areas of entry into the U. S. From the table the following conclusions can be drawn:

1. The increase in imports is in the form of crude oil (from 286,000 barrels daily early in 1948) to about 420,000 barrels daily at year's end.
2. The increase is largely due to shipments of Middle East oil (from less than 10,000 barrels a day in the 1948 first quarter to about 110,000 barrels daily).
3. The increase has been principally in the New York area (from 170,000 barrels daily to more than 200,000 and into Gulf Coast ports (from a negligible volume to more than 30,000 barrels a day).

INCREASED imports of petroleum have become a matter of serious controversy within the industry during recent months. The matter is considered so important that Congress is being urged to take action limiting imports.

It is contended that imports should be reduced, in view of sharply increased stocks and the prevailing necessity of holding down new supply. Domestic crude production allowables have been reduced, it is asserted, and imports should be curtailed also in balancing supply with demand.

In the interest of national security, the U. S. must have a strong domestic oil industry, it is stated. Petroleum imports must be used only to supplement and not to crowd out domestic supply, lest the vigor of the domestic industry be impaired.

Effect of Trend

What is the effect of this trend? Many industry leaders see a threat to the whole domestic petroleum economy as a result. Alf M. Landon, former Republican presidential candidate, wrote President Truman that the oil industry is threatened with a recession unless crude imports are cut.

Russell B. Brown, general counsel for the Independent Petroleum Association of America says: "Rising petroleum imports have contributed directly to the excess accumulation of stocks during 1948 which exceeded necessary levels by more than 70 million barrels on January 1, 1949. There is evidence that they were used for the purpose of controlling prices in 1948. They forced a substantial curtailment in domestic oil production early in 1949. Unless reduced, they will displace domestic oil in the U. S. market by forcing oil production in this country below maximum efficient rates."

Brown cites the 1948 estimated adequate stock level for year end, 1948, as computed by the Economics Advisory Committee of the Interstate Oil Compact Commission:

Four major products, including California heavy crude .....236,300,000 bbls.
Refinable crude .....225,400,000 bbls.

Compared with these estimates, actual stocks as of January 1, 1949, were:

ITEM	Actual Stocks Jan. 1, 1949 (Barrels)	Excess over Adequate Stocks as Estimated (Barrels)
Four major products including California heavy crude	291,871,000	+55,571,000
Refinable crude	243,071,000	+17,617,000
		+73,188,000

The largest part of this excess stock buildup, says Brown, is in the form of fuel oils, "the product most directly affected by imports." He adds: "The large and increasing volume of imports during the last six months of 1948, at a time when they were not needed and when stocks were excessive, naturally raises the question as to why this oil was imported in large volumes. There are several possible answers, but it is significant that this development coincided with a movement by companies without access to foreign supplies to increase the the price of crude oil in this country and further stimulate development and production."

According to the December, 1948, report of the Interstate Oil Compact Commission's economic advisory committee, total export and domestic demand for

petroleum is expected to average 6,517,000 barrels daily for 1949. This demand can be supplied from four principal sources: (1) domestic production of crude; (2) domestic product of natural gas liquids; (3) withdrawals from stock; (4) imports of foreign oil. With a stock excess of 73,188,000 barrels, it is logical —many industry economists argue—that part of the 1949 demand should be met by reduction in these stocks.

A reduction of 45 million barrels would be equivalent to a supply from storage of about 125,000 barrels a day, leaving 6,392,000 barrels a day to be furnished by new production and imports.

One reliable measure of available production in the U. S. is given in the report on long-term availability of petroleum by a committee of the American Petroleum Institute. That report shows an average estimated availability for 1949 of 5,760,000 barrels a day of crude oil and 450,000 barrels daily of natural gas liquids, totaling 6,210,000 barrels a day of petroleum in the U. S.

On the basis of such figures, Brown contends that the need to import to supplement domestic production can be summarized as follows.

Total 1949 estimated domestic and export demand . . 6,517,000 bbls. daily
Less: withdrawals from storage . . . . 125,000 bbls. daily
6,392,000 bbls. daily
Less: availability of domestic production . . . . . 6,210,000 bbls. daily
Balance needed to supplement domestic supply and meet demand 182,000 bbls daily

NPC Report

The historical position of the industry has been that petroleum imports should not retard and discourage exploration for and bevelopment and production of petroleum within the U. S. This policy found support in the National Oil Policy report recently adopted by the National Petroleum Council. The report said in part:

"The nation's economic welfare and security require a policy on petroleum imports which will encourage exploration and development efforts in the domestic industry and which will make available a maximum supply of domestic oil to meet the needs of this nation.

"Imports in excess of our economic needs, after taking into account domestic production in conformance with good conservation practices and within the limits of maximum efficient rates of production, will retard domestic exploration and development of new oil fields and the technological progress in all branches of the industry which is essential to the nation's economic welfare and security."

There are various possibilities of controlling oil importations. Import controls were first imposed in June, 1932, in the form of excise taxes on the importation of crude petroleum and products. These taxes remained in effect until December, 1939, when the taxes were reduced under provisions of a reciprocal trade agreement with Venezuela. A later trade agreement with Mexico made further adjustments in the import taxes and removed a quota restriction that had been part of the agreement with Venezuela.

There are various ways in which imports could be controlled in the future.

1. Control by voluntary action, on the part of importing companies. There is evidence that this technique is being used. Imports of crude from the Middle East by the Standard Oil Company (N. J.), which averaged 88,000 barrels a day during the fourth quarter of last year, will be cut back to 45,000 barrels a day in the first quarter of 1949. Further, recent cut-back production schedules in Venezuela will reflect in lowered imports from that source.

2. Control through the invocation of "escape clauses" in reciprocal trade agreements. In both the Mexican and Venezuelan trade pacts, escape clauses were inserted permitting the U. S. to take action on the favors granted in the event that imports were proving injurious. These escape clauses could be used so as to restore reductions in the petroleum excise taxes, and, more important, to indicate a policy as to the harmful effect of excessive imports.

3. Control through new legislation. Imports of oil could be controlled through Congressional action in a number of ways. New and increased excise taxes could be imposed on the basis of the difference in cost between foreign and domestic oil. Also, Congressional legis-

■ CONTINUED ON PAGE 58

TABLE 1
U. S. Imports and Exports of Crude Petroleum and Its Products—1928-1948
(Thousands of Barrels Daily)

	IMPORTS			EXPORTS			Excess Total Exports Over Total Imports
	Crude Oil	Refined Products	Total	Crude Oil	Refined Products	Total	
1928	218	32	250	52	370	422	172
1929	216	82	298	72	375	447	149
1930	170	119	289	65	364	429	140
1931	129	107	236	70	271	341	105
1932	122	82	204	75	207	282	78
(1st 6 Mo. 1932)	177	123	300	78	240	318	18
(2nd 6 Mo. 1932)	68	40	108	72	175	247	139
1933	87	37	124	100	192	292	168
1934	97	41	138	113	201	314	176
1935	88	56	144	141	212	353	209
1936	88	68	156	137	223	360	204
1937	75	82	157	184	289	473	316
1938	72	76	148	212	319	531	383
1939	91	71	162	197	320	517	355
1940	117	112	229	141	216	357	128
1941	139	128	267	91	207	298	31
1942	34	65	99	93	228	321	222
1943	38	136	174	113	298	411	237
1944	122	130	252	94	477	571	319
1945	203	108	311	90	414	504	193
1946	236	134	370	112	302	414	44
1947	267	170	437	126	325	451	14
1948*	348	158	506	109	259	368	(138)
1948—1st Quarter	280	195	475	96	213	309	(166)
2nd Quarter	327	150	477	113	296	409	(68)
3rd Quarter	367	146	513	121	294	415	(98)
4th Quarter*	418	139	557	108	232	340	(217)

( ) Indicates excess of imports over exports.
* Includes December, 1948, estimated at average rate of October and November.
Prepared by the Independent Petroleum Association of American from data from U. S. Department of the Interior, January, 1949.

TABLE 2
U. S. Imports of Crude Petroleum and Its Products—Year 1948 by Quarterly Periods
(Thousands of Barrels Daily)

	First Quarter	Second Quarter	Third Quarter	Fourth Quarter*
By Products				
Crude Oil	286	338	362	417
Residual Fuel Oil	179	135	140	121
All Other	16	14	7	17
Total	481	487	509	555
By Sources				
Venezuela	256	273	234	272
Neth. West Indies	170	137	138	133
Middle East	9	39	99	110
Colombia	16	24	27	28
Mexico	28	14	8	9
All Other	2	....	3	3
Total	481	487	509	555
By Destination				
New York	170	171	182	203
Penna., Md., Va.	233	234	251	252
Gulf Ports	3	8	14	31
All Other	75	74	62	69
Total	481	487	509	555

* Based on October and November average.
Prepared by the Independent Petroleum Association of America, based on data from the U. S. Department of Commerce, January, 1949.

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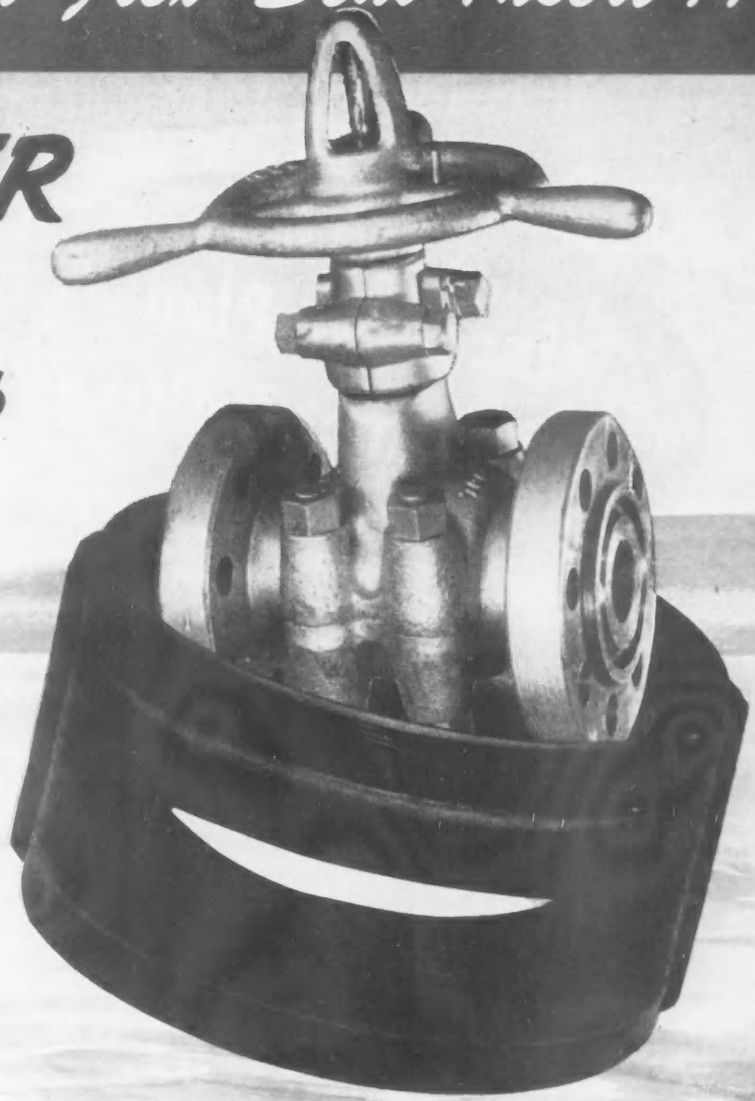

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Benefits of Incentive Plan In Contract Drilling

By GILBERT M. WILSON
Staff Writer

INCENTIVE management plans are playing an increasingly important role in the every-day function of American business. Because of the unseen hazards, financial risks and other problems peculiar to the contract drilling industry, adaptation of such a plan to a business of this type is not simple. Though well realizing the many problems that would be encountered, the management of Thomas P. Pike Drilling Company of Los Angeles approximately two years ago undertook the formation of an incentive management plan. To the credit of all concerned, from rotary helper up to the president of the company, the plan thus far has worked satisfactorily.

Aside from the material and cash benefits which come to employes through their participation in company profits, possibly the most important and immediate result was the increased efficiency and elimination of waste in the every-day operation of the company's 12 rigs. Other benefits immediately noticeable included a decrease in labor turnover, an increase in sales of 65 percent during the first year over the 1947 volume, and a substantial increase in net profit over that of the previous year. As a direct result of its reduced drilling costs, the company has enjoyed a more continuous and sustained volume of business than ever before.

Probably the most important single device through which many of the operational benefits are realized is what the company calls its Advisory Board. This is the management-sharing group whose membership consists of the president, who acts as chairman; and two vice presidents, the treasurer, general drilling superintendent, head mechanic, all tool pushers, and one crew representative elected from each drilling rig. Having a dinner meeting once a month, this Advisory Board has proven a very efficient channel of two-way communication, both up and down, for the free interchange of ideas. It is authorized to discuss and make decisions on matters concerning any and all phases of the company's entire operation. It has provided the opportunity for employes and management to become acquainted and has contributed to the development of real understanding and mutual confidence. It is the group to which is given

A DRILLING contracting company, operating 12 rigs, is making a success of the incentive management plan it initiated two years ago.

Benefits afforded by the plan include generally increased efficiency, elimination of waste, increased drilling speed, fewer fishing jobs, reduction of maintenance and repair costs, better care of equipment, decrease in labor turnover, reduction of accident ratio and insurance rates, increased volume of business handled, and improvement of net profit.

verbally, once a month, company financial data, including profit and loss figures. Monthly reports feature statements on work progress, prospects for new work, a section devoted to safety, analyses of rig down-time that may have occurred during the month, and related matters affecting the company's business.

Paralleling and supplementing the activity of the Advisory Board is a so-called "Junior Advisory Board." This board, headed up by the tool pusher on each rig, is made up of members of the drilling crews, and convenes informally once each month. The results of their meetings are carried to the Advisory Board by the elected crew representatives and tool pushers.

Representing both management and employes, the group above is shown during one of the monthly Advisory Board dinner meetings at which company problems and matters of policy are discussed. In the first row are T. P. Pike, president; O. C. Avey, derrickman; Ernie Edmonds, driller; Ted Alleman, mechanic; Bob Miller, mechanic; Milo Webb, World Supply Company; Winston Murphy, mechanic. Second row Clyde Simpson, vice president; Sam Polan, derrickman; Chas. E. Riemann, secretary-treasurer; Clarence Cramer, tool pusher; W. A. Jones, tool pusher; Verne Coats, tool pusher. Back row Bill Carpenter, derrickman; R. G. Douglas, driller; Otis Coppock, derrickman; Tex Patterson, tool pusher; Les Crabtree, driller; John Fowler, tool pusher; Ralph Smith, tool pusher; Joe Smith, tool pusher; Joe Collum, driller; H. G. Haney, vice president; John Swain, tool pusher.

Financial Incentives

The financial incentive phase of the plan, and in which all employes of more than nine months' employment with the company participate, is a distribution in cash of a predetermined percentage, 25 percent after taxes, of the firm's profits for the preceding fiscal year. At the present time, the proportion or exact amount of participation of each employe is being determined by the Advisory Board, the aim being to arrive at a fair and equitable distribution between the various job classifications that will most closely represent each employe's contribution to the success of the year's operations.

In addition to the yearly distribution of profits under the above distribution system, a plan has been inaugurated under which employes are immediately paid cash awards for worthy operating ideas. Such awards, which may range from $5 to $200, depending on the merit of the idea, are decided upon at the monthly Advisory Board meetings. That this plan has resulted in increased efficiency and productivity in the company's operations is evidenced by the instances wherein employes have made cost-saving suggestions.

Improved Operating Practices

As a direct result of the better care now given tools and equipment, a sharp drop has been noted in the company's maintenance and repair costs. Electrical equipment repairs and costs of rigging up have been lowered. Employes tend to make better use of equipment already in stock or in the company's storage yard.

Increased drilling speed together with a reduction in fishing jobs are reported. These can be attributed to the increased awareness of employes of the importance of care and alertness in their everyday work on the rig floor. Workmen who might otherwise tend to hang back or who might shirk their share of the work, or who become careless, do not, in the eyes of their fellow employes, fit into the picture of becoming eligible for a share of the company's profits.

Specific examples of savings and improved operating conditions suggested by employes, together with a few examples of the size of cash awards granted, are included in the following:

A driller on one of the crews suggested an idea on the improved use and handling of bits. This idea was perfected by one of the superintendents and brought to each of the men a check for $100.

One of the derrickmen suggested that hand tools on various rigs be standardized, with corresponding reduction in costs in stocking and exchanging of tools among rigs. In addition, he suggested certain alterations in the monkey board so as to provide more pipe racking space in the derrick. For these ideas he was awarded $50.

A mechanic whose suggestion was accepted, and for which he was paid $25, recommended that an extra set of hand tools be supplied at each rig during rigging-up operations in order to eliminate the necessity of having men stand around waiting for the proper tool to become available.

One of the drillers suggested that half-inch tag lines be used with rigging-up tools in order to speed up operation. This idea brought him $10.

At one of the monthly meetings it was decided, in the interest of increasing rig efficiency, to standardize on one type and make of union, the changeover to be effected gradually and as old unions gradually are replaced with new ones.

The importance of proper education of the men in handling of valves was brought out at one meeting. It was recommended, for instance, that to prolong the life of a plug-type valve, it is important that the valve be kept in the "open" position when the rig is being moved or is shut down.

One crewman suggested that unnecessary matching, rebuilding, straightening or obtaining of new bolts during rigging-up may be eliminated by tying bolts to their respective fittings with short pieces of soft rope at the time equipment is dismantled.

To provide for the simplified temporary storage and racking of reamers and special tools, such as directional equipment, on the derrick floor, an employe suggested that a series of eight-inch inside diameter rat holes be mounted on one side of the floor, which would be well out of the way of routine operations.

At one Advisory Board meeting a report cited the exceptionally good service obtained by tongs on a particular rig where the practice was followed of thoroughly washing tong teeth and greasing the several moving parts after every trip of the drill pipe.

One of the pushers reported, after a survey of all the company rigs, that installation of a new set of pump valve springs and valve guides can do much to reduce the wear on valves and valve inserts and seats, due to the fact that some of the strength leaves the springs after they have been in use for some time.

It was brought out at one meeting

that in certain instances rental of special tools has been in excess of the purchase price of those tools. It was recommended that in the future, an estimate of the time it may be needed be made beforehand, and if its rental cost should prove to be more than its purchase price, the tool then should be purchased outright.

Stressing the need for devoting more attention to rig maintenance, one employe suggested that periodic and regular greasing jobs be performed on rigs, and this to be done in accordance with a definite chart. He recommended further that a permanent mechanic be assigned to older rigs which generally require more constant attention. It was decided at that meeting that more mechanics would be employed in order to more fully cover each rig.

A plan suggested at an Advisory Board meeting and subsequently adopted requires someone to come on duty at company headquarters at 7:30 a.m. to receive calls from pushers before the beginning of the regular work day. Delays occasioned by congested lines during mid-morning hours thus are largely eliminated.

Because considerable time frequently has been lost in the past due to the fact that new locations have been improperly graded at the time of moving-in, a policy was formulated at one meeting which required that the tool pusher, in advance of moving in his rig, personally inspect the next site. It was suggested further that a clause might be included in future contracts specifying that locations be properly cleared and that they be subject to inspection beforehand by the pusher or other representative of the contractor.

At the suggestion of one employe it was recommended that workmen be alert to the quality of repair jobs or other work done by outside firms, so that in the event of inferior work being done, immediate adjustments can be sought.

To speed re-laying of line pipe at each new location, it was suggested by one crewman that lengths be marked before the line is taken up.

It was recommended at one meeting that existing practices of keeping bit records be reviewed with a view toward eliminating duplication.

A new and improved type of belt idler recently placed on the market was thought by one pusher to be applicable to certain of the company rigs with consequent improved operation of the rigs.

These are but a few of the numerous ideas presented, discussed and acted upon at the monthly meetings of the Advisory Board. Many of the ideas, while difficult of evaluation in terms of dollars and cents, nevertheless are accorded full recognition and are discussed thoroughly. When a workman finds that his idea, although small, but nonetheless important in his eyes, is received favorably by the company, he will be encouraged to greater efforts in the future.

Intangible Benefits Realized

Among the other benefits realized, those which contribute to the over-all efficiency of the company's operations, are the following:

The importance of accident prevention is brought to the attention of crew members constantly, it being demonstrated that substantial savings in premium costs are effected when the company's accident ratio is lowered. So important is this matter of accidents that the company, acting upon the suggestion of some of the employes, publishes in the monthly house organ a detailed accounting of accidents which occurred during the previous month. In the several columns of this monthly tabulation are given the rig or job on which the accident occurred, the name of the injured man, date, a brief description of the accident, and the name of the pusher in charge of that rig. It is believed by all concerned that if an employe is able to see what actually happened to other men, he will be more conscious of the need for exercising extreme care during every minute of the working day.

Another matter taken up at an Advisory Board meeting was that of securing more and better cooperation from the crewmen. It is stressed that such cooperation will be obtained more readily if pushers and drillers will try to lead by example, and that if any criticism is necessary, it be given in a friendly manner and at a time when other workmen are not present.

A friendly spirit of competition between crews of various company rigs tends to develop in the men a sense of good housekeeping around the rigs, a desire to keep equipment in good shape, maintain clean surroundings, etc., all of which contributes much toward increasing the efficiency of operations. A desirable practice recently adopted concerns the breaking-in of a new crew member. Instead of giving this job to a single crew, the new man is rotated from one crew to another, and from one rig to another, thus assuring the man of a more rounded experience under different drillers and pushers. Also, if a new man does happen to prove undesirable, he has the benefit of having judgment passed by more than one driller or pusher.

Wherever possible, the company tries to keep crews located in the same general area, realizing that the men, when moved, are faced with problems of moving their families, taking children out of school and other undesirable aspects of such shifts. As a result of this policy, crews make special efforts to operate their rigs efficiently so that management in turn can be in a favorable position to bid on subsequent work that develops in the same area. Some of the company rigs have been located in one field continuously for two to three years.

As a direct result of discussions initiated at the monthly meetings of the Advisory Board, there now is in effect a Blue Cross Hospital and Surgical Plan, and group life insurance recently was placed in effect. In addition, means have been provided whereby company employes may be assisted when and if they should require financial aid.

Certain other plans have been followed by the company which help to cement relations between management and individual employes. In the monthly bulletins or house organs, "pats on the back" and recipients of cash awards are given prominent display, along with those persons who have been promoted in the company.

Because of their closer contact with the financial end of the company's business, men acquire a sense of security hitherto not felt at the employe level, and which in turn brings about a feeling that when and if hard times should strike, they will have a correspondingly better than average chance of weathering the period satisfactorily. In a similar respect, when a man becomes cost-conscious in the every-day workings of the company, his ideas and suggestions become as important from a dollars-and-cents viewpoint as would an increase received in the contract price of drilling a well.

As the president of the company often has pointed out to the employes, the ability of a company to stay in business and maintain a steady backlog of work depends directly upon its ability to quote or bid with prices low enough to enable it's getting the contract, yet which will allow a reasonable profit return. Since preparation of a bid is based on the current drilling cost, and since costs of operating are directly proportional to the degree of efficiency with which crews and equipment operate, it naturally follows that the ability of the company to stay in business and maintain full employment, rests directly upon the employes themselves.

The results of the program to date have more than justified the belief of the company's management that the best way to assure continued profitable operation with a minimum of hazard and risk is to inject the spirit of team work and partnership.

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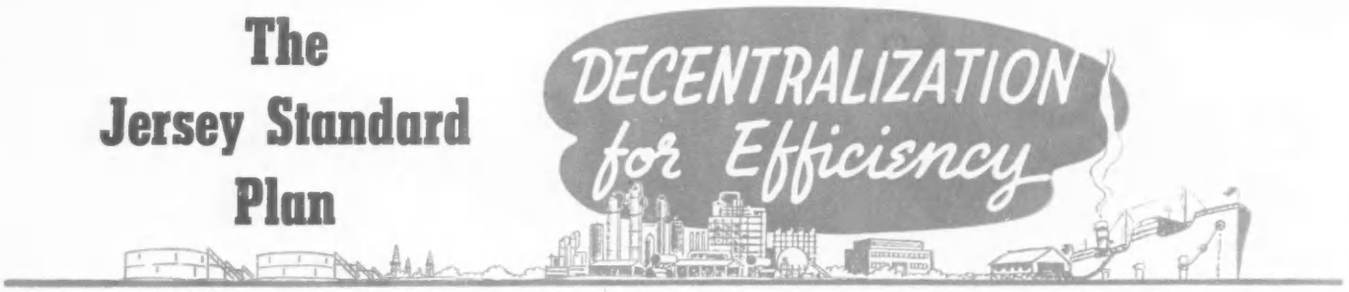
The Jersey Standard Plan



By HENRY OZANNE
Staff Writer

STANDARD OIL COMPANY (N. J.), largest U. S. oil company, operates its far-flung holdings under a decentralized form of management which takes advantage of the initiative, ability, and know-how of executives and employes throughout the organization.

Each of the nearly 200 different subsidiaries and affiliates of the company has its own board of directors and officers, entirely responsible for operations in the interests of their stockholders. Thus fullest opportunity is afforded for expression of individual judgment and authority.

The parent company, through its directors and executive committee, confines its control mainly to reviewing the results obtained from previous investments, to study of proposed investment, and to seeing that all affiliates have capable managements.

In a constant effort to fulfill a large responsibility to the company's customers and the public as well as the stockholders, the directors invite public leaders and experts to its meetings to discuss trends and viewpoints from outside their own group.

THE principles of industrial democracy have been translated into patterns of business conduct by Standard Oil Company (N. J.), proof that the largest company in one of the nation's greatest industries can run itself in the interest of the public welfare. This problem of efficient company operation, which at the same time serves the public good, is one of the most challenging and important facing American business today. If industry demonstrates that it can do that job itself, the system of free private enterprise receives new and conclusive validation. If industry fails to do so, further extension of government controls over business and a regimented economy are inevitable.

Jersey Standard's program of management procedure and public responsibility belies the charge that "big business" is incapable of measuring up to the responsibilities expected of it. A credo of the company stresses: "Because of the importance of oil as a source of energy, the company accepts the view that many governments and people have legitimate interests in our conduct. The management recognizes that conduct in the public interest aand appropriate regard for human relationships form the only possible base of continued profitable operations."

Jersey sees explicitly a four-way responsibility and obligation: (1) to its own stockholders; (2) to the consumers of its products; (3) to its employes; and (4) to the wider public with which it is interrelated at many points. Furthermore, Jersey holds that the appropriate observance of these obligations is the best guarantee of a free business and social order without the burden of undue governmental regulation.

The noteworthy fact about Jersey's conception of industrial democracy is not the mere declaration of policy, but the concrete steps that have been taken to realize it. Year's ago Jersey determined that company thinking must not originate simply at the top and be filtered down. Such a "straight line" theory of management collapses in the face of the problems of mass production requiring huge organizations and complex operations to handle them. Jersey acts on the assumption that policies work only if they have been discussed and have won the agreement of those responsible for carrying them out. This, as the company expresses it, is the Art of Talking Things Over—an essential part of de-centralized management.

First Meetings

Formal recognition in a broad sense of the practice of talking things over started in 1918 when meetings were initiated between management and refinery employes. These discussions showed that company foremen were poorly equipped to deal with many of the problems raised. Foremen training programs followed quickly with the aim of developing a unified team of management and workers.

In meeting this kind of problem the form of company organization as well as the way it actually functions is crucial. The first thing Jersey attempted to do was to give logical orderliness to its corporate structure. At present there are about 125 different affiliated companies of various sizes in which Jersey has investments. Each affiliate, having its own board of directors and officers, is entirely responsible for the operations in which it engages. Thus, full opportunity is afforded for expression of individual judgment and authority.

Jersey owns varying amounts of stock in each affiliate and in some cases owns all the stock. The parent company's chief responsibility is to review constantly the results obtained from previous investments, to study proposed investments, and to see that all affiliates have capable managements. Closely associated with this responsibility is the promotion and maintenance of policies that will foster good relations with employes, customers and the public.

Most illuminating, however, of the Jersey policy is a look at the Jersey company's own organization to see how the plan of de-centralized management works toward the objective of achieving efficiency within the framework of industrial democracy.

Top management consists of a board of 12 directors, including the chairman of the board, president and four vice presidents. All board members devote full time to the company's affairs and the board holds regularly scheduled meetings once a week. All directors before being chosen have had experience in the company and its affiliates as technical experts or as executives with large responsibilities.

Five of the directors constitute an Executive Committee which meets daily. Of these five, four are specifically designated as members of the committee and

the fifth is chosen from the other directors on a rotation basis. Each board member is familiar with the company's business as a whole and is available to operating managements and headquarters staff executives for consultation. For convenience, the board assigns each director and one alternate for contact with designated groups of affiliates as well as for the major operating functions, such as production, transportation, refining and marketing. Such directors make reasonably frequent visits to inspect operations of affiliates.

The board and Executive Committee include on their agenda as items to be considered in a systematic manner:

1. Evaluation of the effectiveness of directorship and officer personnel of each affiliate before granting a proxy for the annual election of directors of that affiliate.

2. Consideration of capital expenditure budgets of affiliates.

3. Review of financial and operating results of subsidiaries. At least once a year the management of each large affiliate is invited to discuss operating and financial results and future prospects with the parent company board or Executive Committee.

The Jersey board invites public leaders and experts to meet with it on occasion to discuss trends and viewpoints, and the board is especially interested in viewpoints which are different from its own.

Agreement of the Jersey board is seldom recorded merely by the formality of a vote. If disagreement exists among the directors, that is taken as evidence that not all the facts are at hand, and board members go back to search out the missing facts on the basis of which they can reach a unanimous decision. In its task of coming to conclusions on the variety of problems with which it deals, the board is assisted by staff departments and committees which supply expert advice.

The board has summarized its description of its own purpose in these words: "To fix responsibility for efficient and effective operation and to develop in the company and in its affiliates a most valuable asset—highly competent executives of broad business experience."

Coordination Committee

Certainly one of the most interesting and important organizational devices within the Jersey structure is the Coordination Committee, the primary purpose of which is long-range planning on a worldwide basis. The functioning of the Coordination Committee affords the best example of the intermeshing of the guiding principles of efficiency and the cooperative interchange of ideas and information toward the end of supplying the public with improved products.

The Coordination Committee is made up of Jersey department heads and some executives of affiliated companies. Its chairman and vice chairman are directors.

A question may arise concerning the type and quantity of products needed for a certain market, and around the Coordination Committee conference table will be experts in producing manufacturing, transportation and marketing, together with representatives of affiliates. Typical problems reviewed by the Coordination Committee concern available supplies of crude oil, including plans for purchases of crude from non-affiliated companies.

These plans must be coordinated with those of Jersey's own affiliates in production, refining and transportation so that markets of each affiliated company may be served efficiently and economically. Decisions to extend producing operations, build new pipe lines or tankers, or to erect new refineries, are all affected by these discussions. Such decisions, of course, are not made by the committee, but still the boards of the various affiliated companies responsible for these decisions are better informed on the problem as a result of the views developed in the Coordination Committee.

The committee also acts as a reporter and observer of industry trends, and continually reviews the activities of the affiliates in relation to those trends as they affect long-range plans.

The committee operates not by arbitrary authority and intervention into the affairs of the affiliates, but by advising the affiliates through appropriate channels of the results of the committee's studies and analyses.

The Coordination Committee includes 14 members as follows:

1. Two members of the board of the parent company.

2. Two officers from general staff de-

Eugene Holman, president, with F. W. Abrams, chairman of the board

. . . and with Jack Cisco, driller.

partments of the parent company (heads of the Budget department and of the Coordination and Economics department).

3. Eight functional specialists, largely from the parent company, such as the marketing coordinator and the pipe line adviser.

4. Two representatives of subsidiary operations, one from the Standard Oil Development Company, and the other from the Esso Standard Oil Company.

Since the Coordination Committee is a study and advisory group to assist operating managements of affiliated companies in planning and meeting business problems, the actual procedure of the committee and the methods used in the preparation of the operating program are important. This may be summarized as follows:

The committee agrees on basic assumptions that underlie the preparation of data by and for the affiliated companies, thus affording a unified objective to its study. Then estimated sales requirements are taken as prepared by the marketing units, and methods worked out for supplying each of the markets at the lowest overall cost. The program is prepared in its final form by the Coordination and Economics department which effects the close cooperation of producing, refining, transportation and marketing interests. Finally, the resulting program is offered as the best thinking of all concerned, not as a blueprint that must be followed rigidly by the operating managements of the affiliates, but as a basic framework for evaluating the effect of changes to meet varying conditions.

The effectiveness of the Coordination Committee depends in part on its relations with several staff departments. One of these is the Budget department, the head of which is a member of the committee. The several functional coordinators (producing, pipe line, refining, marketing) keep informed on their specialties through their staffs and by contact with those affiliates engaged in the functional activity which is their direct concern. They make recommendations on their functional activities and join with the Coordination Committee in consideration of matters having broader ramifications.

Committee Aided by Staff

The principal staff of the committee is the Coordination and Economics department which has about 90 employes. It is in three divisions: (1) the general economics division which has about 13 specialists and eight other employes, and which makes broad studies of the general economic situation all over the world; (2) the petroleum economics division (about 40 employes) which compiles data on the petroleum industry world-wide; (3) the coordinating division staffed largely by engineers which studies the current operations of the companies in relation to the over-all operating program.

The Coordination Committee has as major standing sub-committees one on world-wide supply, another on budget, and ten others on major functions as well as standing and temporary sub-committees for special problems. The Coordination Committee and its sub-committees are the main channel through which major policy problems are brought up for consideration by the various executive and operating departments. There is no problem of rivalry, but rather an attitude of cooperation between the Coordination Committee's sub-committees and the committees created elsewhere.

The Coordination Committee holds an annual meeting to which executives of all affiliates are invited. This meeting is much like that of a scientific society, and its attendance may reach 250 persons. Technical and administrative papers are read, and much time is reserved for general discussion over a four-day or longer period.

One other important way in which Jersey Standard has met the challenge of democratic operation is exemplified in the company's long recognition of the need to find and develop men and women to fill management positions in the parent organization and with its affiliates. The program has been more than simply training employees to become efficient administrators; recognition has been taken of the "human relations" factor in the company's team of about 100,000 employes scattered over the earth and speaking more than a dozen languages.

The manner in which this problem of developing executive personnel is met through the establishment of training programs, arrangements for the interchange of executive personnel, etc., as proposed, recommended or instituted by various agencies and committees of the parent company, illustrates the flexible manner in which a broad subject may be considered and the manner in which central committees may help mold policies without exercising direct supervision of the detailed arrangements.

Company's Philosophy

One director of Jersey sums up the company's philosophy in these words:

"It is becoming clear that in our modern society top management has the opportunity—in fact, I should say the duty—to act as a balance wheel in relation to three groups of interests—the interest of owners, of employes, and the public, all of whom have a stake in the output of industry. They can best represent the interests of ownership by acting fairly and wisely with respect to the claims of employes and the public as well. It is a difficult but vital role. It seems to me only too obvious that the very survival of private enterprise requires that private enterprise act to maintain a productive and equitable relation among these three elements; the individual's right to, and the social necessity for, profits; the economic and human aspiration of all workers, and the public's demand for an abundance of goods at low cost. The alternative is plainly intensified industrial conflict followed by increased government regulation forced by an impatient public.

"One essential is to see that integrity is developed and exemplified at all levels of management insofar as possible. The problem lies in the attitude and methods of leadership of all who are responsible for harmonious group relationships. The necessity of extending the sense of responsibility is the essence of effectively managing large enterprises which function through widely scattered operating units.

"Progressive management must realize that over-all efficiency is a product not only of scientific management in the strict sense of the word, but of wise *human* relations."

Jersey has found that this combination of decentralization and democratic form of central coordination which it represents goes a long way toward solving one of the most fundamental problems of large-scale management today. That problem is how to maintain the advantages and efficiencies of bigness and at the same time create the kind of environment in which the individual has every opportunity for personal growth and development. The solution of that problem Jersey has found in terms of real freedom which decentralized management provides.

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Profitable Progress Through Research

By EDGAR A. JETT, II
Assistant Director, Armour Research Foundation

WELL-PLANNED and vigorously executed programs of research are profitable to oil companies and the petroleum industry as well as to the public. Important subjects of research in the petroleum industry currently include new methods of geological and geophysical exploration, new materials to overcome metal shortages, better drilling machinery and equipment, secondary recovery methods, oil refining processes, synthetic fuels, improvements in pipe line systems, larger and faster tankers, improved engines, oils for metal cutting processes, diesel engine fueling and lubrication, aircraft lubricating oils.

THE best kind of planning is necessary in a world where oil means power, and as the industrial economies of all nations become ever more hungry for petroleum products, research programs must be more daringly conceived and vigorously pursued.

To a reassuring extent, we can today predict through research further developments and impending trends. Although American scientists and engineers claim no mystic powers of divination, they are laboring diligently on future methods and ideas for industry. What these trail-blazers are accomplishing, or even what they expect to accomplish, is of vital interest to members of the petroleum industry, since new products and techniques coming from the nation's laboratories will determine many decisions for business.

Research is a form of business insurance when it is well planned and contains well executed programs. Such a schedule has proved itself profitable to producers as well as to consumers. It is better to have scientists and science working for and with an industry rather than at cross purposes.

Great research laboratories now being constructed and expanded in various parts of the country by those engaged in the petroleum industry are concrete evidence of the confidence these companies have in scientific development and the future welfare of this nation. Numerous research projects assigned to company laboratories and independent organizations are additional proof of practical interest. Research is not for the benefit of a favored few, but will affect producers, refiners, marketers and all consumers through the media of reduced production costs, additional volume in production, economical sales methods and ultimate consumer satisfaction. As a matter of interest, it is well to mention here a few of the specific possibilities through research:

New methods of geological exploration for additional reserves will be of tremendous value. New materials can help overcome various metal shortages, particularly that of steel, standing in the way of expansion by producing companies. Better drilling machinery to produce crude oil more rapidly and economically would be welcomed in fields throughout the world. At the moment exciting developments are taking place in Colorado on one formation of shale rock containing an estimated 300 billion barrels of oil. Through the medium of mining, retorting and refining research with shale oil, prospects for a great new source of fuel oil are excellent.

Research in the field of secondary oil recovery continues. There are an estimated 700 million barrels in the Pennsylvania fields alone awaiting secondary recovery, valued at more than $3 billion. Only about 50 percent of the original reserve has been recovered.

Refiners have developed better safety inspection and cleaning procedures, and have effected considerable savings which are passed along to both stockholders and consumers. In the field of chemical additives there is much research activity, which is expected to result in an upward turn of quality as competition makes itself felt more strongly. It can be predicted safely here that there will be advancement of quality standards

through more evaluation tests and identification procedures.

In the field of synthetic petroleum, research shows that products which include the conversion of natural gas into motor gasoline and the transfer of coal into petroleum products by hydrogenation are no longer dreams but facts. It is a matter now for research and development to reduce the costs of such products.

Marketers will find that faster and more efficient use of pipe lines, tankers and tank cars will be necessary in order to supply an expanding market. Supply lines of the oil industry are expected to improve greatly, contributing an important competitive factor. Long range merchandising programs, including extensive market research, have been difficult to predict through the postwar years, due to the fact that so many things do not happen as predicted by the "experts." It seems now that these merchandising programs are in sight and should strike a balance between cooperation and competition. There should be a definite improvement of such items in the oil industry as containers; and who can tell whether or not there will be disposable gasoline containers? Twenty years ago no one would have given the slightest credence to the fact that milk could be shipped and preserved in a disposable container which would contain, protect and preserve the product.

These are a few examples which serve only to introduce us to possible research activities among the persons who bring oil products to America's consumers. Horizons are unlimited, according to scientists and engineers now at work on these and related projects, and we have only to look at the history of the oil industry to know that, without research and planning, the mean product of the oil companies today would still be crude oil under the commercial name of "kerosine."

Oil Industry Projects

Here at Armour Research Foundation of Illinois Institute of Technology an important part of industrial research being conducted by our staff members concerns itself with the petroleum industry and its products. Since the writer is rather closely associated with these projects, it might be well to mention a few of the more significant ones:

An engine research laboratory conducts standardized engine tests for the evaluation of fuels and lubricants for various members of the petroleum industry, chemical additive manufacturers, engine builders and makers of component parts.

The function and effect of oils in metal cutting processes are being studied under simulated service conditions, with the end view of improving the product and fitting it to the job.

Lubrication and fuel problems common to large-bore, slow-speed diesel power plant equipment are receiving close attention. Aircraft lubricating oils have been evaluated, including checks of piston cleanliness, connecting rod bearing weight loss and discoloration, piston ring weight losses, cylinder wear and piston ring sticking tendencies.

Geologists at Armour are conducting stratigraphic research directed toward the location of new oil fields, through a more inexpensive method than is now used.

A project sponsored by a certain oil company for the purpose of eliminating the explosion hazard created by small quantities of acetylene in oxygen produced by air liquefaction has been successfully concluded.

What this will mean to this company in safety measures is immeasurable at the moment.

Combustion chamber deposition of operating spark-ignition engines received exhaustive examination, and methods for the evaluation of such deposits have been developed after considering the influence of the fuel and lubricant, engine speed and temperature, and other operating conditions.

A program for the identification of oil from one part of the country has been in operation for three years. Identification methods are infrared absorption and refractivity intercept. A further extension of this product is being considered now with the object in view of a correlation between composition and quality.

Additives which occupy the professional attention of Armour Research Foundation staff members include ignition accelerators, detonation suppressors, deposit inhibitors, economy improvers, detergents, dispersants, corrosion inhibitors, pour-point depressants, catalytic pacifiers, film-strength additives, oxidation inhibitors, foam stabilizers and extreme pressure compounds. Studies of petroleum solvents and secondary oil recovery round out the program.

This is a very rapid and cursory survey of one organization's research operations with petroleum and petroleum products, and will give some indication of the breadth of effort now being expended on scientific development. A significant point is that this research is being sponsored for varied purposes but always with the general objective of profitable progress.

It has been wisely said that preaching to the converted may be pointless. Members of the petroleum industry who have seen gratifying results of patient research ought to spread the word and become missionaries so that all not now benefiting from research programs may come into the fold and add their know-how and experience. A careful examination of the history of scientific research, along with the programs now going forward, should convince many others. A look at the record is a most practical method of arriving at a conclusion.

Scientists in Overalls

One expert has referred to scientific research personnel as "scientists in overalls" when their efforts are directed toward problems of immediate interest to industry. Applied research is a proper function of technical people. However, it must be borne in mind always that fundamental research is necessary to accumulate knowledge which can then be carried forward into applied research. An old cliche states that before building the trap to catch an animal, it must be decided what kind of animal is to be trapped . . . and furthermore, never set a mouse trap for a bear.

Fundamental research should be encouraged because the accumulation of

■ CONTINUED ON PAGE 58

About the Author

EDGAR A. JETT II is assistant director of Armour Research Foundation of Illinois Institute of Technology, prior to which he had been director of sales for the Great Lakes district of General Electric Company. As a colonel in World War II he commanded a Third Army tank team and served as allied military governor of Luxembourg. Decorations include Croix de Guerre of Luxembourg and Purple Heart with two palms. His last war assignment was with the Inspector General in Washington, D. C., where he worked with industry on quality control and production. He studied national and international economics at the University of Cincinnati, Oxford University in England, and the University of Edinburgh in Scotland.

Regarding Tidelands Controversy

Hoolihan: Mister McGillicuddy, hiv you read the arthicel by Attoorney Gineral Tom Clark dafinding Federal dominion of marginal land the oceans, which is printed in the Dacimber ishew of the *Texas Law Review?*

McGillicuddy: I hiv not.

Hoolihan: Well, nather hiv I, but me son Tim, who is with Lagel department of the Sandland Ile Company, tells me that Mister Clark says that the original 13 states h'd nary title to the tidelands, because at the time we won our indaypindence from England there was no international law or custom recog'-nizing ownership, and that recog'-nition only took place after the formation of our union. Now, Mister McGillicuddy, will you plase tell me who owned those tidelands during the hexistance iv the 13 states and before the formation iv the Union?

McGillicuddy: Well, Hoolihan, I see what you mane. It is true that, once discivered, the title to land is visted in somewan or some country, and it only passes by will, inheritence, or by the owner selling it or another country grobbing it by force of ayrms, but in this case we are daling with a nebulous title, and it was in a state of soospense until the federal givernment decided that it wanted it.

Hoolihan: I am glad, Mister McGillicuddy, that you used that word nebulous, because Mister Clark used it whin he says that ownership by the states at the time we won indaypindence from England was a nebulous suggistion. Will you be good enough to tell me what is a nebulous suggistion?

McGillicuddy: Well, Hoolihan, to put it in plain wurds, a nebulous suggistion is wan that is hazy to the person who makes it, or to the person to whom it is addrissed, but it is not necessarily hazy to both of thim. F'r instance, if Mrs. Hoolihan were to suggist to you that you allow her to sign checks on your bank account, that would be a nebulous suggistion. You will raymimber that Roosia made a nebulous suggistion to Finland that she wanted to hiv territory along the Finnish Gulf,

Messrs. McGillicuddy and Hoolihan are old Pennsylvania pipeliners, who came to the Southwest in the early days of oil development, built many miles of pipe line, are now retired, and spend their time "saving the country." Hoolihan recognizes the greater erudition of McGillicuddy, and the latter is inspired to justify that recognition.

By H. F. MONTGOMERY
Former President
Texas Civil Judicial Council

and the Eyetalians made a nebulous suggistion to Haile Selassie about property rights in Etheopeea.

Hoolihan: Timmy tells me that Mister Clark says that ownership iv the tidelands is an incident iv national soverainty, and that none iv the original states were soverain in the troo sinse. Do you supposes that Mister Clark has forgotten that Texas henjied national soverainty for more than tin years, during which time it had consoular and diplomatical officers abroad and recaved those of furin nashuns here, and do you suppose that he thinks that Travis and Fannin and Houston were hivin target practice at the Alamo, Goliad and San Jacinto?

McGillicuddy: No, Hoolihan, I do not belave that Mister Clark has given much thought to the history of Texas as a nashun. In fact, I do not belave that in his early youth he was given much to the stoody of history, and that, on the ither hand, most of his time was davoted to the stoody of political economy. It does look as though he is approaching a time whin his knowledge of Texas history is going to be expanded and umbellished.

Hoolihan: Mister Clark says that because the states hiv been permitted throughout history to hiv jurisdiction over fish, eysters, clams and spunges presints no rason why the states should hiv control iv the mineral resources underlying the marginal sea. I don't see why there shud be any diff'rence betwain the two sources of wealth.

McGillicuddy: I think, Hoolihan, maybe I can make the distincshun clear to you by wan exomple. When Timmy was a small lad and had a piggy bank, you let him play with it as much as he wanted to and as long as he wanted to until it became full, and then you remimber you took it away from Timmy and emptied it, and put some iv the money in a savings account for him.

Hoolihan: That reminds me that Mr. Clark says that after the fideral givernment takes over these tidelands the givernment expects to pay 37½ percint iv the nit income to the state along whose shore the tidelands are sithuated. Now, Mister McGillicuddy, if the fideral givernment owns the title to these lands and the state niver owned any title to them, why should the fideral givernment contribute 37½ percint iv the nit income to the state?

McGillicuddy: You should not be so skiptical, Hoolihan, but raymimber that a givernment can hiv a conscience as well as a man.

Hoolihan: But Mister Clark says that these tidelands belong to all of the peaple in the nashun, and yit he says that the givernment expects to distribute 52½ per cint iv the income to the Western states for reclamation projhects. Now, tell me, Mister McGillicuddy, just how are all the peaple of the nashun going to injye the benefit of these rasources if 52½ per cint iv the income is put into reclamation projhects in the Western states?

McGillicuddy: Hoolihan, you are an incredhulus induvidual. It ought to be asy for you to undherstand that money put into reclamation projhects produces dams for the purpose iv impounding whater, and that this whater in turn is disthributed over the desert land of Califurnia and other Western states, and as a consequince froots and viggitables are grown, which are shipped throughout the nashun, and thus all the peaple benefit.

Hoolihan: Mister Clark has a good Irish face, and I cannot understand how he has gone so far asthray. Tim tells me that he got his law license in Texas, but I suppose there is some simularity betwain law licenses and huntin licenses and I raymimber that you don't hiv to show that you own a shotgun whin a'plyin f'r a huntin license.

McGillicuddy: You shud hiv more patients, Hoolihan, with men in public life. Mister Clark has been in Washington a long time. It is a paculiar climate. Along the Valley iv the Potomac, and particularly in the District iv Columbia, there is indaagenous to that area an insect known as the chortlebug, which is about one-half the size iv a Texas moskeeto, but twice as viroolent. Very few of the residents iv the District iv Columbia have escapted its infaction. The arly simtoms of this desase give wan a sanctified appearance, like an alderman on his way to confission. Later the hearing is affected, and is attuned only to the tones of expadiency. There is a faraway look in the eyes, always staring upward to the higher roong in the political ladther. The desase is progrissive, but in Mister Clark's case I am shure it will be completely arristed whin he faels the judishal ermine risting sacoorely on his shoulders.

Hoolihan: Your definse of Mister Clark is nather satisfyin nor convincin.

McGillicuddy: Well, Hoolihan, there are many things in this wurruld which are nather satisfyin nor convincin, but which you hiv to take on faith. In this particular case, it must be taken on faith in the Supreem Coort.

Hoolihan: Since you have brought up the Supreem Coort, tell me, Mister McGillicuddy, just how the Supreem Coort is going to joostify takin from Texas the three marine legs, or about eleven miles of tidelands, which Texas retained at the time it came into the union?

McGillicuddy: Well, Hoolihan, the Supreem Coort has not deputized me to speak for it, but you will raymimber that Texas jined the Confideracy and withdrew from the Union during the war betwain the states, and the coort might hold that when Texas came back into the Union she was recaved stripped of her three marine legs as effectooly as a strip tase dancer doffs her skirts, leavin only a G string, which may be compared with the eyster and fishin rights left to the states. However, the fideral givernment has always taken the position that Texas was niver out of the Union, but in a matter of sich vaast importance as these tidelands the coort might hold that that continshun was made without prejoodice to holding differently where the facts call for distingshun.

Hoolihan: And what do you mane by "without prejoodice," Mister McGillicuddy?

McGillicuddy: Well, let me give you an exomple: Suppose after being out until after 2 o'clock in the mornin playin poker with your cronies, you gintly open the front door, and you hear your wife call to you harshly from the top of the stairs and ask where hiv you bin. Although you hiv lost twinty dollars, you will promptly tell her that you won tin dollars, and hand it to her with a car-ress. Now that situation is without prejoodice to your right to tell her the trooth the next time you lose the same amount but get home by tin o'clock pay m. In ither words, there may be a distincshun without a difference, but there is niver a distincshun for which some rason cannot be invinted.

Hoolihan: Me son Tim tells me that it is not necessary for judges of the Supreem Coort iv the United States to be li'yers.

McGillicuddy: That is true, but the noble experiment was niver thried until Mr. Roosevelt's administration.

Hoolihan: Tim also tells me that most iv the mimbers iv the coort get their law by absorpshun and exposure.

McGillicuddy: Faith, and Tim is an upstart, and that is a base canyard that ill befits a young man who shud hiv a higher concipshun of aythics. Furthermore, it does the coort a gross injoostice, because I am shure they stoody the former opinyuns iv the coort, in order to carefully distinguish them from their own bether considered dacasion.

Hoolihan: So you think the present Su-

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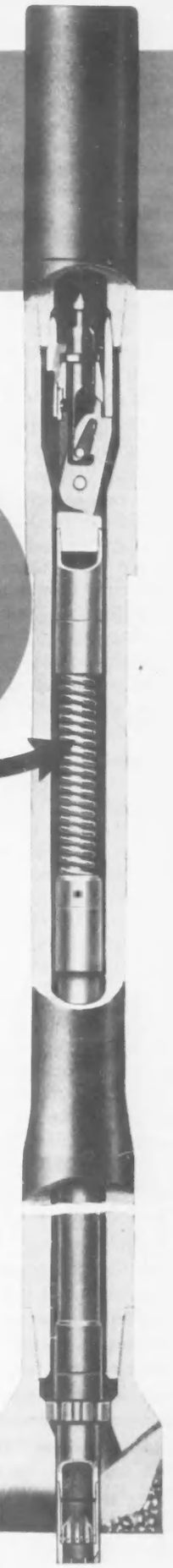

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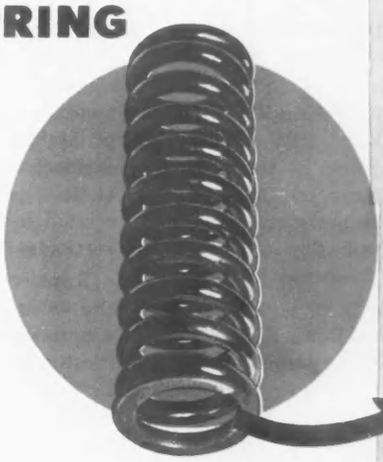

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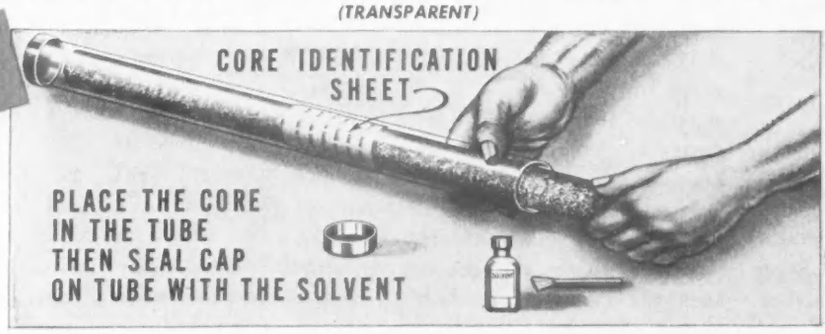

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preem Coort is entitled to our respict?

McGillicuddy: Indade I do. I hiv some friends who differ with me slightly, and wan in particular, who says that the opinyuns iv the present coort hiv characteristhics similar to the progheny which he sacures from crossing a Brahman bull with grade Hereford cattle. The Brahman bull wurruks harder on his job than the purebred Hereford bull, and he gets more progheny, such as they are, - long-legged, - lop-eared, - unpleasant to look at, - difficult to get hold iv, and he finds that he shud get what he can out of thim on the current market, as they grow to less value each year.

Hoolihan: Tim says law is but rason timpered with joostice.

McGillicuddy: That seems to be wan of those rare occasions whin Tim is substantially correct in his opinyun; however, his perspictive is too circumscribed to conform to the laborall viewpoint. Law is but rason timpered with joostice and the ellymint of joostice further tempered by the will of the majority.

Hoolihan: Don't you think the Supreem Coort should stick to sound principles of law?

McGillicuddy: Sound principles, yis, but the present Supreem Coort don't seem to think that all of the sound principles are to be found in the auld law reports, so the great melthing pot of their decasions contains a leetle from the index on the cost of livin, a leetle more from the crop reports, a ginerus helpin from the eleckshun returns, and a pinch from the auld musty opinyuns.

Hoolihan: Tim tells me that the prisent coort has no rispect for starecisis.

McGillicuddy: You spak iv it as though it was a contajus or inficshus desase, which it is not, but it is about as welcum to the prisent Supreem Coort as your red flannels are to you on the Furth Day of July. What Tim is talking about is the docthrine of Stare Decisis, which has to do with settled principles iv law, but, as I hiv told you, the prisent coort possheses full confidence that it can declare its own pricidents bether than borrowing from the former coorts, who knew nothing about radar, television, atomic bombs, rocket bombs, open-toed shoes, soap flakes and Dixiecrats.

Hoolihan: I gither, Mister McGillicuddy, that you belave the contintion of Texas in dafince iv her tidelands is sacure

McGillicuddy: Faith, and I do, but I would rist a mite asier if the faathers of the Texas Republic had had the fursight to make the resirvation in thray dimenshuns.

Profitable Progress Through Research

■ CONTINUED FROM PAGE 54

basic knowledge is necessary, and, although it may not pay immediate dividends, the end results can be amazing.

Research in related fields interests progressive members of the petroleum industry, as evidenced by the fact that the development of new engines requires new fuels. We are noting a trend in the automotive industry toward different engine designs; and the fuel industry, as such, should be ahead, not abreast or behind, these developments.

While the relationship of other types of research may not be so obvious, close study of the whole general field of scientific investigation undertaken for the benefit of industry can prove highly profitable to those who are keeping themselves abreast of the times. Conversely, petroleum research has affected related industries such as paint and insecticides.

Research is in the public interest, and the value of good will acquired through a better product sold at a lower price is inestimable. Not to be overlooked is the fact that training scientists and engineers to know more about petroleum products than ever before is a good thing for the country. This is particularly true since oil is politically potent and our national security depends to a large extent upon our oil supply. Many experts say that an increase of our petroleum resources would be a major factor in maintaining our economic strength and giving us military superiority in the event of war.

The enlightened programs of research going on all over the U. S. not only show the alertness of the petroleum industry to changing times but a comprehension of responsibility. It is this layman's view that the petroleum industry boasts many enterprising men with the vision and courage to push back the frontiers of scientific knowledge in their field. These are wide frontiers indeed, with wealth behind them; but the paths ahead will twist and wind, end in cul de sacs, and discourage all but the hardiest.

These paths should be followed, and . . . . where there are no paths . . . new ones should be constructed, bearing in mind that, "to the fearless and daring go the spoils of victory." That victory will mean better products, more products, economical production, intelligent merchandising, public good-will, profit, and, above all, satisfied consumers. It is believed that such a program should and will be followed.

Imports Issue Splits Industry

■ CONTINUED FROM PAGE 44

lation could be adopted providing for quota restrictions based on a determination of actual volumes of imported oil that might be needed, or on some relationship between petroleum exports and imports that would insure sufficient domestic development to meet national requirements.

4. IPAA suggests that oil imports could be curbed by application of the Anti-Dumping Act of 1921. This act provides relief in the form of special duties, which might be considerable, on imports where an industry in the U. S. is being injured through importation of a commodity which is being sold in the U. S. at a price less than it is being offered for sale in other chief world markets.

In general those industry economists who contend that domestic production is being retarded below maximum efficient rates argue for control and curtailment of oil imports. Those, on the other hand, who foresee an inability to meet demand—not only U. S. but world demand — argue for expanded petroleum imports. Between these two positions in their extreme statement, there are many middle grounds. One of these is taken by Interior Secretary Krug who warns against dependence on foreign oil, but is still pessimistic abount finding enough oil in the U. S., and believes that development of synthetic oil is the answer to the problem.

Krug testified before Senator O'Mahoney's Interior Affairs Committee last month: "Any gap that appears between domestic productive capacity and demand could be filled with supplies from proved oil resources abroad. Assuming cheap pipe line and tanker transportation to the U. S., freedom from exorbitant taxes and charges for oil concessions in foreign lands, and the construction of facilities, such oil would provide a quickly available and presumably low-cost supply.

"However, from the standpoint of military preparedness, the risks are great if we rely on such sources. The increasingly important Middle East oil fields are supplying more and more oil to Europe and to the U. S. For the remainder of the oil we look to South America and the Caribbean area. In time of war, loss of the Middle East fields could means the end of any effective western European war effort. It would be exceedingly difficult for the Western Hemisphere to increase its production at a rapid rate, for little reserve productive capacity is available."

Oil Prospects *In Basin Areas*

By GAIL F. MOULTON
Staff Geologist
The Chase National Bank
New York City

The presently known oil reserves and those yet to be discovered within the U. S., including the coastal waters, comprise our oil resources. The proven reserves are the subject of estimates made public annually by The American Petroleum Institute. The undiscovered portion of our oil and gas resources is the concern of this paper. In it the discovery prospects of the more important potentially productive areas are evaluated in terms of general geologic knowledge.

IN THE future, the important additions to the oil and gas reserves of the U. S. will be discovered in the deeper portions of the sedimentary basins. This conclusion is based on the status of exploration of the sedimentary areas, the volume of untested strata in cubic miles, and the geology of these strata as presently known.

The discovery prospects for some basins appear to be much better than for others. Some have been explored to a large extent and their important contributions to the oil and gas supply are already known; others have been partially explored and data are available for their general evaluation as sites of future discovery, while others are so little tested that their potentialities are entirely a matter of speculation to be determined by considerable exploratory effort.

The following discussion outlines in general terms the typical geologic history of favorable areas and presents a statement of some of the factors which permit exploration of new areas in the future on a basis more favorable than in the past, but is mainly devoted to a summary of data leading to conclusions as to the status of exploration and relative merits for exploration of the more important basins containing sedimentary rocks. These conclusions are summarized in an accompanying table and map.

General Geologic History of Favorable Areas

Geologists, in their research, long ago recognized that certain areas of the earth had a tendency to sink during long geologic eras. In the portion of such geosynclinal areas adjacent to land masses, muds, sands, and coarser materials were deposited, the locus of this clastic deposition changing as the land masses and embayments changed in elevation, size or location. Simultaneously, there was deposition of chemically and biochemically precipitated materials in quieter waters, giving rise to strata of chalk, limestone and salt as well as the other types of strata with which these materials are characteristically associated. In general, these processes of deposition continued in certain regions over such long periods of time that even after compaction under the pressure of deep burial, the total thickness of the indurated sediments reached many thousands of feet. Usually the sequence of strata included source material for oil and gas and porous beds, capable of accumulating and producing oil and gas at commercial rates. Eventually, the epochs of deposition were interrupted or terminated by uplift or mountain building movements during which there was folding and faulting of the rocks. Thus, in a sedimentary basin, all of the fundamental conditions for the accumulation of oil and gas in commercial deposits are potentially present.

In most sedimentary basins the mountain building epochs were periods of erosion during which the higher structures tended to be planed off to a more nearly level surface. Erosion of high areas commonly divided the original basins of deposition into smaller areas of sedimentary rocks occupying structural basins. In many cases there was later deposition of sediments in these new basins, covering the older strata with flat or gently dipping beds which reflect the older structures poorly, or not at all. Thus, at the present time, the geologist and oil and gas producer are engaged in exploration to discover remnants of the original oil and gas accumulation, often seeking them below a mask of later deposits.

The preceding paragraphs outline in summary the following sequence of events: (1) accumulation of sediments in large areas of deposition; (2) termination of an era of deposition by earth movements, in some cases of mountain building proportions; (3) erosion of sediments from high areas; (4) resumption of deposition in newer basin areas which in some cases were fragments of previous basins. This discussion is concerned primarily with the present sedimentary remnants in major structural basins. The term "basin" as used herein refers to a structural depression containing important thicknesses of sedimentary rocks.

Modern Exploration

Improved exploratory technique and greater drilling depth capacity have made it possible to leave the areas of relatively thin sedimentary deposits along important regional anticlines, on structures near the margins of major basins and the vicinity of salt domes having surface expression, and to attack the problem of finding oil and gas in the deeper portions of the basins in which great thicknesses of sediments are found. Considerable success has attended these efforts during the past decade. Important refinements in geophysical methods permit the interpretation of structural conditions to depths of 15,000 feet and more, and modern drilling equipment permits the exploration of geologic features which may be found at such depths. Consequently, structural basins in which the probably productive formations are expected at great depths may be explored, and have attracted exploratory effort because of the large size of productive structures being found under these conditions. The following discussion of the basins, therefore, is particularly concerned with areas where surface evidence of structural conditions is of doubtful significance and where drilling depths are great.

Oil and Gas Prospects of Basin Areas

Most of the more important sedimentary basin areas of the U. S. are shown on the accompanying map, Figure 1. The map is not intended to show the precise location or area of each basin, but is a general reference guide for purposes of identification.

The classification of the discovery prospects of the basin areas is largely dependent upon an interpretation of geologic conditions. Geophysical surveys may provide data on the folding of buried strata, but in the central portions of the larger basins exploration by drilling is necessary to determine the location of satisfactory reservoir rocks. Consequently, it must be recognized that in addition to the known geological condi-

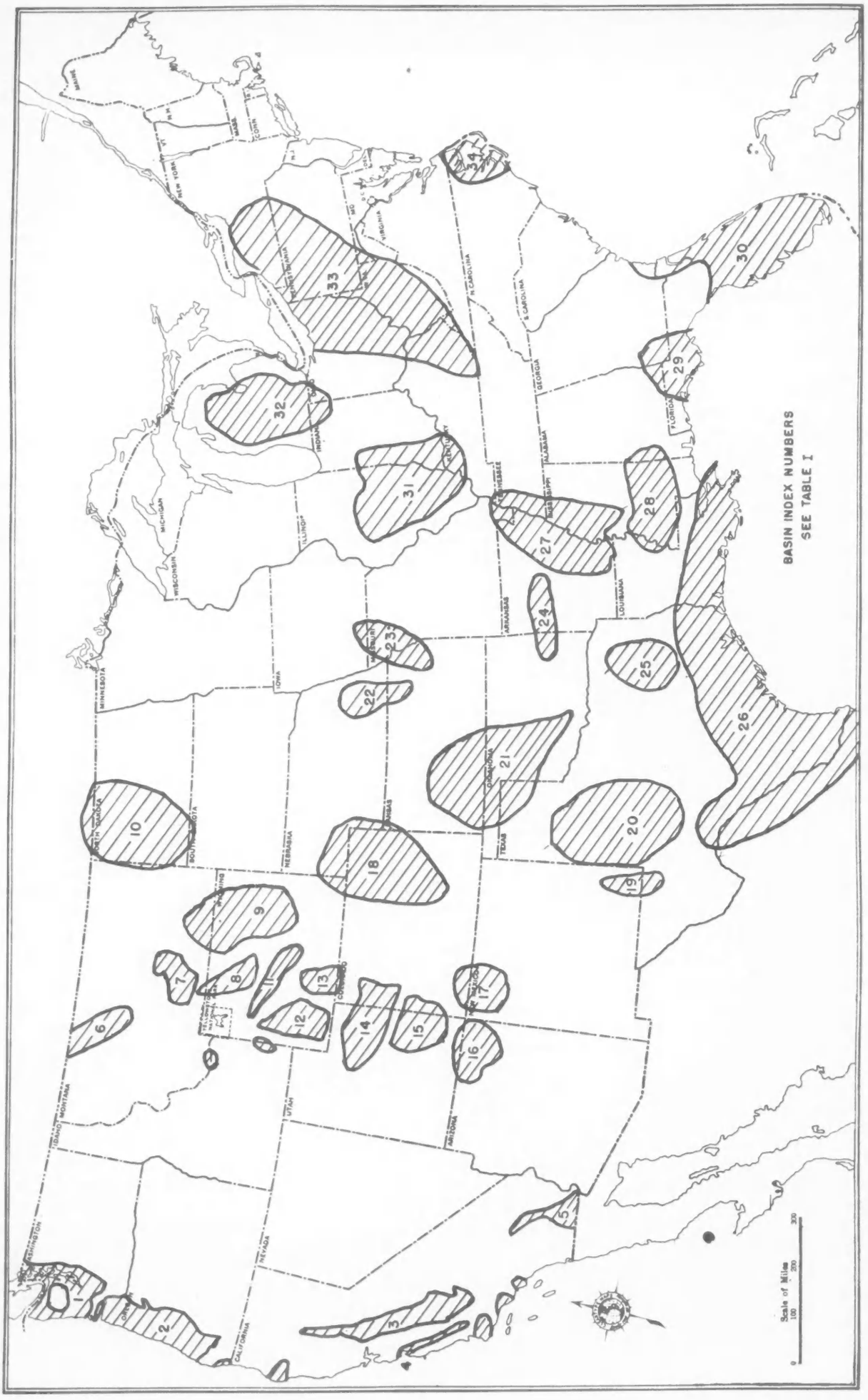
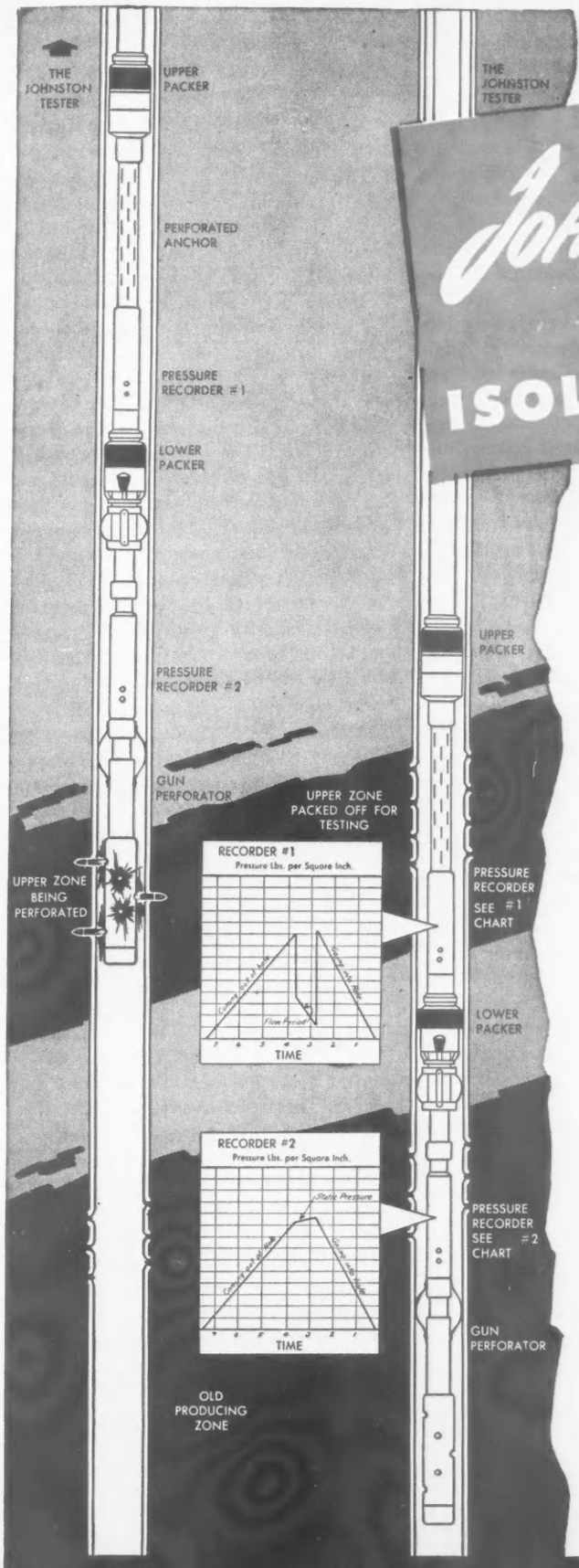


FIGURE 1



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tions, the status of exploratory drilling must be considered in each case.

Table I lists each of the areas numbered on the map, gives some of the published data as to the area and volume of each basin, and classifies each in accordance with the author's personal opinion as to discovery prospects. The scheme of classification used is designed to indicate the status of exploration as well as the predicted future of exploration results. The key to the classification is as follows:

Prospect Classification

A. Considerable exploration, good oil and gas reserves
   1. Both additional areas and greater depths to be tested. Probable discoveries very important.
   2. Main prospects in structures obscured by shallow formations. Good discoveries likely.
   3. Remaining undiscovered reserves probably of moderate size.

B. Some exploration, some good fields
   1. Excellent prospects for additional reserves.
   2. Fair prospects for additional reserves.
   3. Future discoveries of importance doubtful.

C. Some exploration, results inconclusive
   1. Prospects of discoveries appear good.
   2. Prospects of discoveries appear fair.
   3. Prospects of discoveries appear poor.

Most of the basic information for Figure 1 and for Table I was obtained from "Future Petroleum Provinces of North America," a symposium of the AAPG published as the May 1941 number of the Bulletin, the "Tectonic Map of the United States," prepared as a research project of AAPG in 1944, and the U. S. Geological Survey's "Geologic Map of North America." Modification and expansions of these data will be recognized. Exploratory drilling since the date of these publications has provided further information as to the oil and gas prospects of some of the basin areas and has been considered in the preparation of this paper.

Of the Pacific Coastal areas, only No. 3 has been explored extensively. Additional discoveries of moderate size appear probable for this area. Marine sediments of considerable thickness are known in the other coastal basins, and recent exploration indicates the probability of further discoveries in No. 4. It is possible that volcanic activity subsequent to the deposition of the potential oil and gas bearing sediments in the northwest has adversely affected areas Nos. 1 and 2.

The basins in the Rocky Mountain states are believed to have generally good discovery prospects. Area No. 6 in northern Montana is given a low rating because of the extreme difficulty of solution of exploration problems arising from the very complicated structure of the mountain front area. It must be recognized, however, that one or more fields of the Turner Valley type might be found even though there is little encouragement in drilling results thus far. The south central Montana basin, No. 7, contains many well defined anticlinal structures which have been tested through the Cretaceous formations with unfavorable results. Older formations, which are not well known, remain to be tested in the area and recent discoveries in them prove prospects of production are fairly good. Area No. 9 has exploration problems yet to be solved, but older fields in the southern part of the Powder River Basin and recent developments to the northeast permit an optimistic view of the future of the area

The remaining basins in Wyoming are rated highly because of excellent results obtained in exploration and the large areas of thick sediments yet to be explored. The basins to the south along the Colorado-Utah boundary appear likely to contain important oil and gas reserves. A major oil field has already been discovered in No. 14 at Rangely and a major gas field in No. 17 at Barker Creek Dome. Further, the Church Buttes field in No. 12 is proving to be a very important gas reserve. Comparable geological conditions in other parts of these basins will probably be found and should lead to the discovery of similar fields. Exploration of these deeper basin areas will be hampered by the thick cover of undisturbed strata and by difficulty of access to the areas, but the prospects of ultimate discovery appear good.

In the western plains area, the Williston Basin, No. 10, does not seem particularly promising, for at least one important structure has been tested without favorable results. Area No. 18 thus far is productive only along its western margin; elsewhere it is largely unexplored and is believed to have fair prospects of oil and gas discovery in the large volume of sediments remaining to be explored. The relatively small Delaware Basin of West Texas and southeast New Mexico has similar prospects. The large Midland Basin is already known to contain large reserves of oil and gas, and in recent years has been the scene of some of the best discoveries in the U. S. Recent additons to geologic data indicate further important volumes of sediments meriting exploration with every expectation of similarly satisfactory results.

The northernmost basins of the Mid-Continent area have been explored to a considerable extent, and on the basis of the poor results to date and the relatively small volume of sediments to be tested, are not considered to have important prospects. Although only a small portion of the Anadarko Basin, area No. 21, has been explored, the substantial discoveries made in the southern portion of the basin combined with the expectation of favorable geological conditions over much of its large area and the large volume of sediments to be tested lead to the conclusion that discovery prospects are good. Recent developments substantiate the favorable rating given this area, and are considered indicative of the type of successful exploration which will be carried on for a long time to come. The McAllister Basin, No. 24,

About the Author

Gail F. Moulton was graduated from the University of Chicago in 1920 and took an M. S. degree in 1922, majoring in geology with chemistry and mathematics as minor subjects. In 1917 he had summer employment on the Illinois Geological Survey, followed by several months of work in Oklahoma and Texas for Roxana Petroleum Company prior to a brief period of military service in 1918. During the field seasons of 1920-21-22 he worked for the U. S. Geological Survey in Wyoming and Montana. For two years after receiving the M. S. degree he taught geology at the University of South Dakota. From 1924 until 1943 when he became staff geologist for The Chase National Bank, New York, he did petroleum work for the Illinois Geological Survey; was geologist and manager of the Geological Department of United Gas Company at Houston; went to New York as staff geologist for Electric Bond and Share Company; engaged in reserve estimates and evaluation work and directed drilling programs in Montana and Pennsylvania; served as vice president of Ralph E. Davis, Inc; and was an independent consultant and oil producer.

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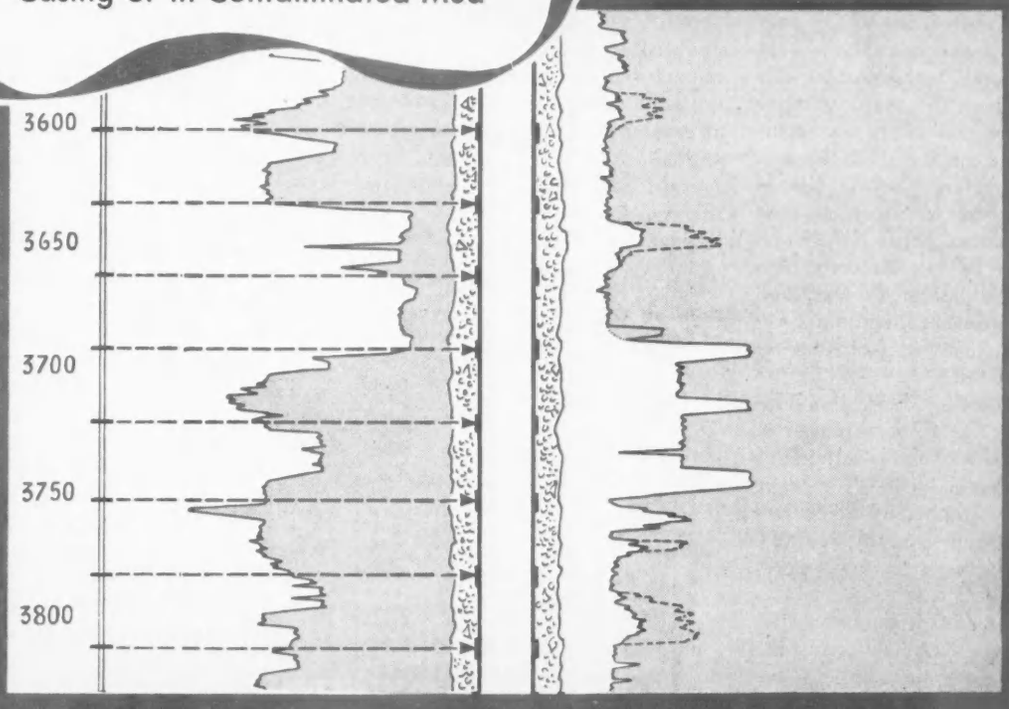

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has fairly good discovery prospects although the generally poor quality of the reservoir beds indicates that only modest reserves are likely to be found.

Exploration of the Illinois and Michigan basins, Nos. 31 and 32, is not complete but is sufficient to indicate that only unimportant oil and gas discoveries are likely. Much larger volumes of sediments remain to be explored in the Appalachian Basin, No. 33, but widely distributed wells have penetrated the entire thickness of prospective producing formations and provide evidence that the old sediments remaining to be tested in this area include only a very small portion of potential reservoir beds, and that these generally are of poor quality. Discovery of additional reserves of local importance is anticipated, but the prospects of making substantial contributions to the nation's oil and gas supply do not appear very good.

Potentially productive formations have been deposited along the Atlantic coast from the vicinity of New York southward, across Florida and along the Gulf Coast. These formations extend inland for considerable and varying distances and were also deposited out to the submerged borders of the continent. Only the areas of general depression in this area are indicated on the map, for elsewhere the marine sediments are comparatively thin and apparently lacking in potential source materials. Area No. 34 is little explored, but does not appear to have much promise. Areas No. 29 and 30 may prove to be satisfactorily productive, but further data on the variation in character of buried sediments are required before conclusive exploration results can be obtained.

The middle and lower Mississippi Valley area, No. 27, has been explored in part without encouraging results. The Mississippi salt dome basin, No. 28, is known to contain important fields and has excellent prospects for additional discoveries, particularly in formations at considerable depth.

The East Texas salt dome basin, No. 25, is of modest volume but appears likely to contain important additional reserves to be discovered after additional well data permitting the solution of geologic problems have been obtained.

The Gulf embayment area of the Rio Grande Valley, which extends for a considerable distance back from the present Gulf and along it to the Mississippi comprises the largest volume of most promising sediments of any basin in the United States. Exploration has been extensive and in recent years drilling depths exceeding two miles have become a commonplace. During the exploration of the past 30 years, important reserves have been discovered in various buried shore line trends which roughly parallel the present coast. In most portions of the area, exploration to depths of one mile has been sufficient to have discovered most of the important oil and gas fields. Exploration in parts of the area, notably in the Agua Dulce - Stratton - Seeligson sector, is even now proving the existence of substantial additional reserves, and will probably continue to do so for a few years to come.

For the future, exploration of the Gulf embayment may be expected to yield important discoveries in at least three different classes: (1) deeper zones present below known structures now productive; (2) deep zones on geologic structures without expression in strata now tested; and (3) new structures on the submerged parts of the continent. Although many of the more important structures have been tested to important depths below the present producing zones, the continuing success of deep drilling in some fields, and particularly around the flanks of the salt dome structures, provides a basis for confidence that such discoveries will be important. In regard to the second and third classes, it may be pointed out that the volume of untested sediments below 1½ or two miles in depth is very large in this area, and undoubtedly contains good reservoirs now unexplored both at the same geologic horizons which are now producing, but at greater depth, and at geologic horizons which are not now known to contain porous zones. The offshore and submerged areas are clearly in a very preliminary stage of exploration by drilling, although extensive geophysical surveys have been completed and are being continued. The solution of geological and geophysical problems necessary to discoveries in this area is confidently expected and will be accelerated by final determination of the ownership of the mineral rights in those portions of these areas now in dispute. It is believed that the average thickness of the unexplored sediments in the Gulf embayment approximates 1½ miles. Therefore, the volume of these unexplored sediments exceeds the total estimated volume of sediments in any of the other basins in the U. S. Since it is believed that their average quality as source and reservoir beds exceeds that of most other basins, it is concluded that the most important undiscovered oil and gas reserves of the U. S. are located in this area.

TABLE 1

Data on Oil and Gas Discovery Prospects of Sedimentary Basins in the United States.

Map No.	Basin Name	Area Square Miles	Total Sediments Cubic Miles	Prospect Classification
1	Puget Sound	21,000	35,000	C-2
2	West Oregon	22,000	35,000	C-3
3	Sacramento	22,000	50,000	A-3
4	Salinas	3,000	4,000	B-2
5	Imperial Valley	5,000	6,000	C-3
6	N. Montana-Mt. Front	1,900	3,800	C-2
7	South-Central Montana	2,000	4,000	B-2
8	Big Horn	3,000	9,600	A-2
9	Powder River	32,000	80,000	A-2
10	Williston	34,000	42,000	C-3
11	Wind River	2,500	6,000	B-1
12	Bridger	10,000	20,000	B-1
13	Washakie	7,000	14,000	B-1
14	Uinta	13,000	18,000	B-1
15	Colorado River	19,000	25,000	C-1
16	Black Mesa	12,000	18,000	C-1
17	San Juan	12,000	16,000	B-1
18	Denver	36,000	70,000	C-2
19	Delaware	8,000	15,000	C-2
20	Midland	43,000	75,000	A-1
21	Anadarko	45,000	90,000	A-1
22	Salina	60,000	36,000	C-3
23	Forest City			
24	McAllister	12,000	18,000	B-2
25	East Texas	14,000	21,000	B-1
26	Gulf Embayment	135,000	400,000	A-1
27	Mississippi Valley	33,000	30,000	C-3
28	Mississippi Salt Dome	21,000	42,000	B-1
29	Southwest Georgia	12,000	18,000	C-2
30	Florida	38,000	75,000	C-2
31	Illinois	37,000	25,000	B-3
32	Michigan	28,000	25,000	B-3
33	Appalachian	94,000	210,000	B-2
34	Hatteras	9,000	18,000	C-3

Summary and Conclusions

Geological considerations indicate that the additional reserves of gas needed for the markets of tomorrow will come from the deeper portions of the important sedimentary basins in fields which will be discovered by exploration for oil. Important additional oil reserves will also be discovered in these areas. The average depth and pressure of these reservoirs will be greater than that of the present proven reserves. As a result, larger portions of these new reserves will be producible by natural flow and most of the gas for pipe line use without field compression. Larger portions of the gas reserves will be associated with oil accumulation and produced at relatively uniform rates over a considerable number of years. As for the gas supply, the important future discoveries which are confidently expected in the basin areas, when added to the proven reserves of today, should prove adequate. These additional reserves will be available in a number of important sedimentary basins. The group of Rocky Mountain basins, the Midland Basin, the Anadarko Basin, and the Gulf Coastal Basin appear to be the best prospective areas. In spite of the considerable past exploration there, future prospects in the Gulf Coastal area are believed to be much greater than in any of the others.

It is recognized that the classification of the prospects of the numerous basins listed in the table probably will be proven erroneous in many instance, but if it stimulates discussion and thought on the problem of our oil and gas resources, the most important objective of this paper will have been achieved.

ACKNOWLEDGMENTS

The Chase National Bank has kindly permitted the preparation and presentation of this paper. L. F. Terry and L. E. Skousen, and other members of the Petroleum department, gave generous assistance in its preparation. Publications of the American Association of Petroleum Geologists, U. S. Geological Survey, and American Gas Association have been used as sources of basic data as indicated in the report.

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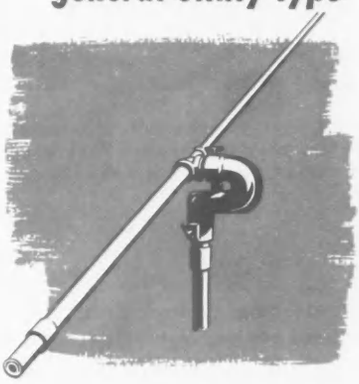

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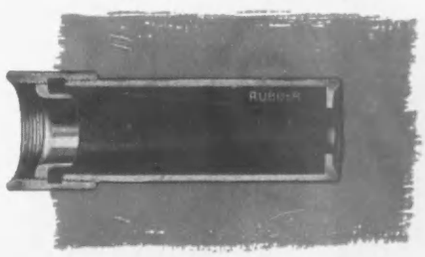

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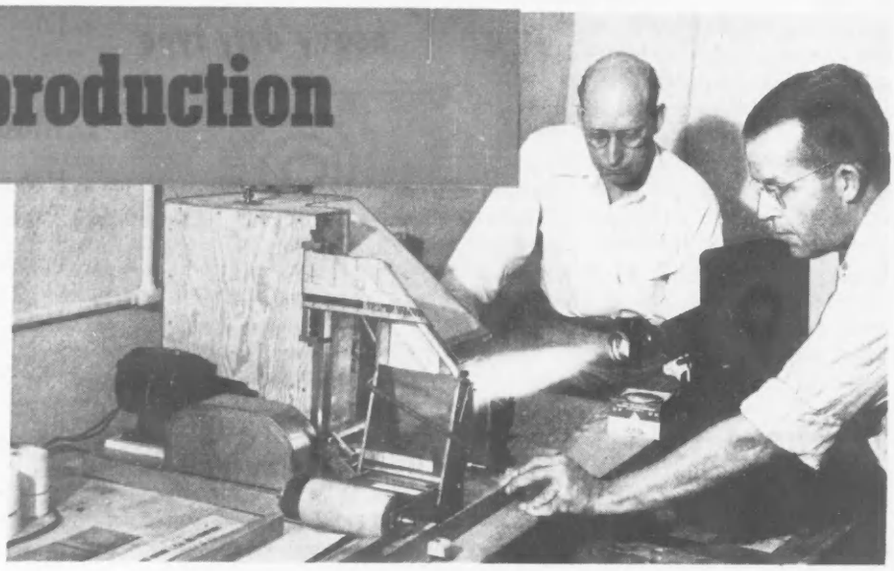
Color Reproduction of Well Logs

By JOHN H. SPEER
Instructor in Geology
University of Oklahoma



James B. Highfill, right, operates camera to make duplicate of strip log as John H. Speer, acting as geologic advisor, observes operation. Note intense beam of light from projector at left focused on original log as it moves through camera at rate of two feet per minute.

A NEW APPLICATION in the technique of color photography has resulted in a fast, economical method for duplicating well logs in full color and complete detail. The process represents more than a year's experimentation which not only involved chemical processes but also the construction of a special camera and other laboratory equipment.

THE strip log, as used by the oil industries for recording geological information, has been evolved over a period of years and forms one of the most useful tools of the geologist. No other device has been found which will provide the same amount of information in so graphic a form and such complete detail as the present strip log.

The essential feature of the log as used today is the representation of data by color, 20 shades or more being used on some of the more detailed logs. Not only is the microscopic examination of the cuttings represented by colors but the driller's log, casing record, drilling time, electrical logs, and other data are also placed upon the same strip, resulting in a complexity of colors and lines confusing to the layman, but to the geologist and engineer a concise and complete record of an oil well which may have cost $½ million to drill. As the logs increase in detail, the time and labor involved becomes a very large factor in making a duplicate. In many cases the original logs are used until they become soiled and worn, and the original detail is obscured, simply because the necessary time and labor were not available to make an accurate copy.

The photographic method of duplication now makes it possible to have a direct copy from the original in true color and detail and without the necessity of checking for errors which may arise in hand copying.

Duplicate logs are used in many ways. District geological offices in many cases will send a log to the head office as each well is completed and often to other district offices which may be interested in the same general area. It now will be possible to have a complete file of logs of key producing wells and wildcat wells at both district and main offices. This makes it possible for research work to be done without having to send a man to the district offices or having the original logs sent to a central office and thus depriving the district office of their use.

Many times an area will suddenly be-

■ CONTINUED ON PAGE 72

Color development of the duplicate log is done at carefully controlled temperatures and with exact timing. Highfill watches laboratory worker place log in one of several solutions through which it will pass during development.

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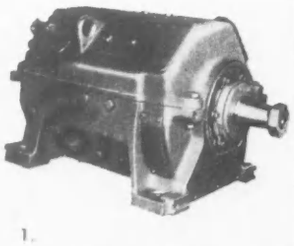

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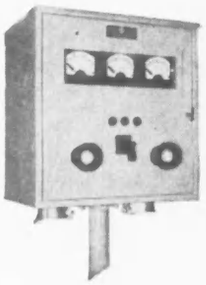

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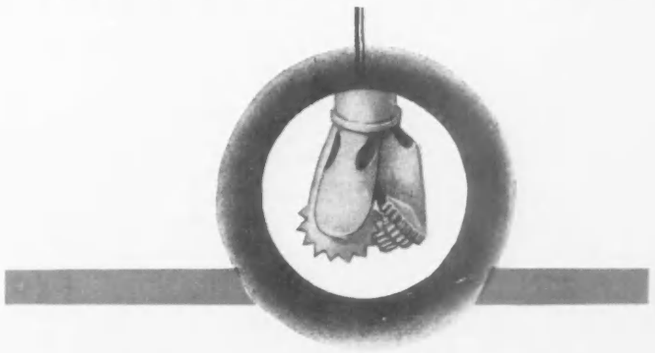

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California Well First to Drill

Below 18,000

By CECIL SMITH
Staff Writer

THE deepest well ever drilled is now under way in California and is still drilling deeper. This well, a wildcat, is being drilled by the Superior Oil Company, the same firm which sank the previous world's deepest in Oklahoma almost two years ago.

Since 1947, Superior's Weller 51-11, in Caddo County, Oklahoma, held the world's record of 17,823 feet, but that operator's latest, Limoneria 1, has passed this mark and has become the first to reach 18,000 feet. At last report this exploratory test was drilling well below the 18,000-foot level and still going.

Limoneria 1 is in 9-2n-22w, North Montalvo area of Ventura County, and was spudded in September.

While one of the current crop of wildcats has set a new record, wildcat drilling in general so far in 1949 has been considerably short of record levels. This year began, as most in the past, with a slump in exploratory well completions from those drilled in the last several months of the preceding year.

Exploratory Completions Up

January's exploratory completions totaled 497, against 640 in December. In January, 1948, wells completed totaled 511, which shows that activity in the month just passed dropped 2.7 percent when compared with last year. However, 1948 was a bit unusual as the customary drop in completions during January did not occur, and actually drilling showed a slight increase.

Although January of this year did not measure up to either December or January, 1948, in total exploratory drilling, it did show a slightly better success average. Out of 497 tests drilled, 102 were productive for a success ratio of 20.5 percent of the total, while in December, 129 producers amounted to 20.2 percent. In January a year ago, 97 successful tests amounted to only 19 percent of the 511 completed.

The month's exploratory drilling re-

Results of Exploratory Drilling January, 1949, by States

STATE OR DISTRICT	JANUARY, 1949-1948																		
	PRODUCTIVE TESTS											UNPRODUCTIVE TESTS						
	New Fields			New Pays			Extensions			Total Productive					Total Dry		Total Exploratory Tests	
	Oil	Dist.	Gas	Oil	Dist.	Gas	Oil	Dist.	Gas	Jan., 1949	Jan., 1948	Wildcats	New Pays	Out-Posts	Jan., 1949	Jan., 1948	Jan., 1949	Jan., 1948
Alabama												1			1	1	1	1
Arkansas	1			1						2	1	3			3	9	5	10
California	2						1			3	2					23	3	25
Colorado												2			2	7	2	7
Florida												2			2	1	2	1
Illinois				3			2			5	6	34			34	30	39	36
Indiana	5									5	3	20			20	11	25	14
Kansas	6		1				1			8	6	31			31	36	39	42
Kentucky	1									1	2	1			1	3	2	5
Louisiana	3	1	1		2					7	8	15			15	13	22	21
North Louisiana	1	1	1		1					4		8			8	5	12	5
South Louisiana	2				1					3	8	7			7	8	10	16
Maryland																1		1
Michigan	1						2			3	2	31			31	19	34	21
Mississippi												6			6	9	6	9
Montana											1	4			4	6	4	7
New Mexico				1						1	4	3			3	7	4	11
Ohio											2	4			4	5	4	7
Oklahoma	5			2						7	7	39			39	49	46	56
Pennsylvania												1			1		1	
Tennessee	1									1		2			2	2	3	2
Texas	26	3	5	13	4	1	2			54	51	188		2	190	178	244	229
Dist. 1—South Central	1									1		17			17	11	18	11
Dist. 2—Middle Gulf	1	3	2			1				7	8	10		1	11	23	18	31
Dist. 3—Upper Gulf	3			4			2			9	8	26			26	22	35	30
Dist. 4—Lower Gulf-S.W.	1			4	2					7	8	26		1	27	27	34	35
Dist. 5—East Central											2	5			5	11	5	13
Dist. 6—Northeast			1		2					3		4			4	10	7	10
Dist. 7-B—North Central	11		2	2						15	7	57			57	29	72	36
Dist. 7-C—West Central	2									2	3	2			2	6	4	9
Dist. 8—West	2			1						3	7	9			9	12	12	19
Dist. 9—North	5			2						7	8	32			32	27	39	35
Dist. 10—Panhandle																		
Utah												1			1	2	1	2
West Virginia			1							1							1	
Wyoming	1			2			1			4	2	5			5	2	9	4
Total United States	52	4	8	22	6	1	9			102	97	393		2	395	414	497	511

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sulted in 74 new oil pools being added to the nation's total. These were 52 new oil fields and 22 new oil pays in existing fields. In the same month a year ago, new oil pools numbered 66, being 42 fields and 24 new pay horizons. New gas and distillate discoveries numbered nine and ten respectively, to show no change from those found in January, 1948.

Meanwhile, wildcatting is continuing at a fairly rapid pace, although some areas report ventures in remote territories have been shut down due to rain and snow.

This is particularly true in the Rocky Mountain Region. However, shutdowns due to heavy weather is not unusual for this region at this time of the year. It is customary for mountain-side operations to halt for the winter and await warmer weather before resuming.

In this region, Superior is at work on another deep test. In Sublette County, Wyoming, Superior's Unit 1, wildcat in the Pacific Creek area, is drilling below 16,000 feet. This test has already established a new drilling depth record for the Rocky Mountains. Little information is being released on this venture, but it is known that it is equipped with the industry's largest rig, which is reported to be capable of drilling to 20,000 feet.

On the same general Oklahoma block that was partially evaluated in 1947 by Superior's Weller 51-11, then the world's deepest well, the same firm has staked Cogdill 33-18, a scheduled 10,500-foot test. The initial test was in 11-8n-12w, and the new location is in 18-8n-11w.

Discovery Reported

One of the tightest wells ever drilled in the oil industry's history is Sinclair Prairie Oil Company's Lipps 1, Roberts County, Texas Panhandle. Strictly unofficial reports say the test has found oil between 9000 and 9500 feet, believed by some to be in the Mississippi formation.

Despite the lack of information from the operators, some significance may be attached to the sparse reports due to the geographical location of the well. It is one mile south of the Roberts-Ochiltree County line and 16 miles south of the town of Ochiltree. Along with two tight holes drilled by Phillips Petroleum Company and the active no-information well being drilled by Gulf Oil Corporation in Lipscomb County, the test is a part of the so-called "big play" which follows a general southeast-northwest trend across southwestern Oklahoma and the northern part of the Panhandle, off the north flank of the Wichita-Amarillo Uplift. The "play" also includes the highly-touted Elk City field, Beckham County, which is one of Oklahoma's hottest new areas, as well as other important explorations in Oklahoma's Washita and Caddo counties.

Wildcatting is showing a definite upward swing in the southern half of Louisiana. There is no particular hot spot, but it is a rather widespread exploration program for the entire section.

Another producer has been added to the continental shelf off Louisiana by Humble Oil & Refining Company, and while it is not a strict wildcat it still belongs—as do all Gulf of Mexico operations—in the hazardous drilling class. The well is Caminada Pass, State Lease 804-D, 1, Tract 1114, Block 6, Jefferson Parish, and bottom of the bore is 1500 feet southwest of the surface location of the discovery well. This is the second producer in the recently discovered Caminada Pass Area field, and was being tested by the operators at last report.

Summary of Results of Exploratory Drilling.

ITEM	Jan., 1949	Dec., 1948	Jan., 1948	Percent Diff. Jan., '48-'49
Oil Discoveries	74	82	66	+ 12.1
New Fields	52	55	42	+ 23.8
New Pays	22	27	24	— 8.3
Distillate Discoveries	10	18	10	.....
New Fields	4	9	3	+ 33.3
New Pays	6	9	7	— 14.3
Gas Discoveries	9	15	9	.....
New Fields	8	13	5	+ 60.0
New Pays	1	2	4	— 75.0
Total Discoveries	93	115	85	+ 9.4
Extensions to Fields	9	14	12	— 25.0
Oil Fields	9	11	10	— 10.0
Distillate Fields	....	2	1	—100.0
Gas Fields	....	1	1	—100.0
Total Productive Tests	102	129	97	+ 5.2
Dry Holes	395	511	414	— 4.6
Wildcats	393	509	408	— 3.7
New Pays	....	....	1	—100.0
Outposts	2	2	5	— 60.0
Total Exploratory Tests	497	640	511	— 2.7
Percent Productive	20.5	20.2	19.0	.....
Percent Dry	79.5	79.8	81.0	.....

(See Tables on 74, 76.)

Color Reproduction of Well Logs

• CONTINUED FROM PAGE 68

come "hot" and it becomes necessary for a geologist to be on the spot. Again, copies of well logs in the area become one of the major sources of information and a ready file of duplicates for such emergencies may be worth a hundred times their cost.

Geophysical parties are furnished logs for the purpose of determining constants of density and velocity, and the recognition of reflecting horizons in the field may be facilitated by a geological study based on the information furnished by the available logs. In letting a contract for drilling, the contractors are furnished logs of the locality in which the well is to be drilled and their estimates of costs depend largely upon the conditions to be expected as shown by the logs. This factor may be of much importance in contracting for a well in wildcat territory.

Sample Service Logs

One field in which a wide use for color duplicates exists is in furnishing logs by sample services. At the present time a black and white log is made in which the various beds are shown by standard symbols. The detail of these logs is limited by the fact that the symbols must be large enough for recognition and in many cases where a single pencil line of color would serve, it is necessary either to omit the feature or to place it by the use of explanatory notes. Most subscribers to these services will go to the trouble of coloring in the log to make it more useful. With the ability to furnish a log in full color a more detailed description of the samples may be made, using a standard range of colors instead of the conventional black and white symbols.

The saving in time and money involved in making duplicates of logs depends upon the detail and accuracy desired in the copy. The photographic method, where direct comparison has been made with hand copying, has proven much more economical even for the duplication of a single copy, and if more than one copy is desired from the same original the costs become even less. Personal errors and the necessary checking of the copy against the original is eliminated and an exact copy assured.

The problem of duplicating well logs in color was given to the Color Research organization by a research geologist of a major oil company who had found the laborious hand method of making a copy of his extremely detailed logs time consuming and costly. Adaptation of ordinary photographic methods proved difficult owing to the peculiar shape of well logs, which may be 15 feet or more long.

A special camera was built in which the original log passes on rollers beneath the lens of the camera in synchronization with the paper in the body of the camera. No negative or color transparency is used as the process is a direct copy from the original. The exposure is rapid, with the log passing under the lens at an average rate of two feet per minute. Orthodox methods of color development are used to complete the process and the log when completed is the same scale as the original. There is no limit to the length of the original log which may be duplicated as strips up to 50 feet long can be easily handled.

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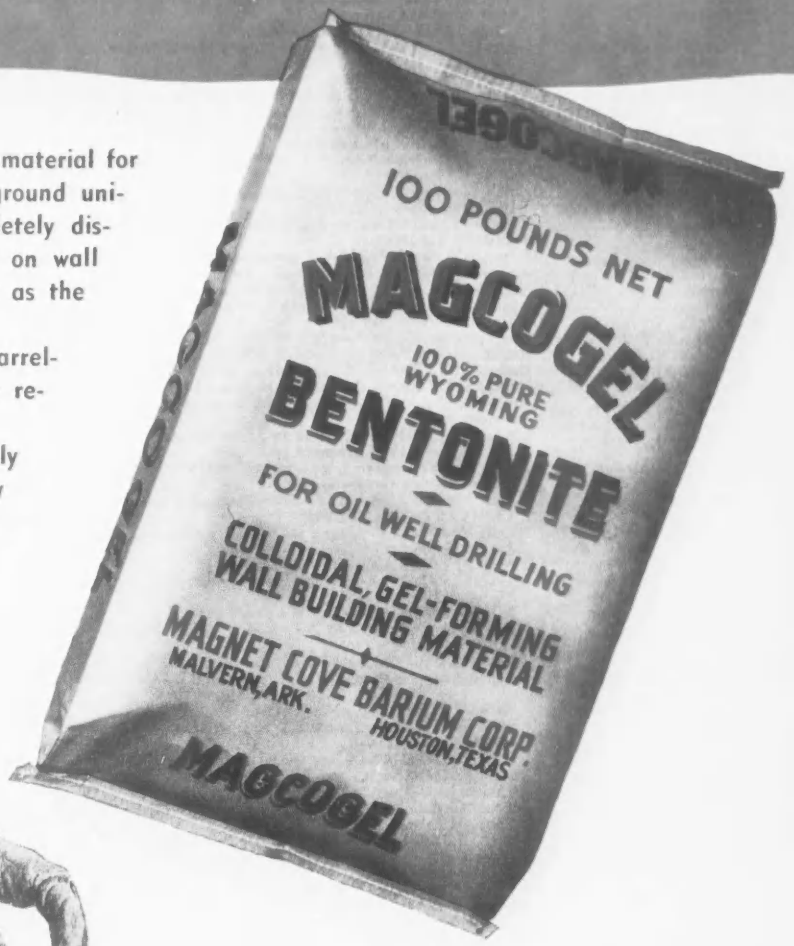

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New Oil, Distillate and Gas Fields and New Pay Horizons Discovered in the United States in January, 1949
Also Important Extensions to Established Fields

COUNTY	FIELD	COMPANY, WELL AND LOCATION	Date Completed	Total Depth (Feet)	Completion Horizon (Feet)	[1]Name, Character and Age of Producing Formation	[2]Initial Production Method and Choke	Gravity of Oil
		ARKANSAS—New Oil Field						
Columbia	Pine Tree	Lion Oil Co's Story 1, c ne se 20-18s-19w, 3 mi n & 2 mi s of Atlanta Twp.	1-21-49	8476	8426- 8433	Smackover li; Jur	F 555; 8/64"	44
		ARKANSAS—New Oil Pay						
Lafayette	Spirit Lake	Joe Mucher's Chas. B. Moore K-1, 350 fr sl 560 fr el, sw ne 14-16s-25w	1-24-49	4200	3965- 3990	Glenrose sd; L. Cre	F 144; 8/16"	35
		CALIFORNIA—New Oil Field						
Monterey	Los Lobos	The Texas Co's Aurignac One 4, 1624 s 1702 e fr n¼c Sect 4-23s-10e, 1½ mi sw San Ardo fld.	12-28-48	2780	2611- 2750		P 60; 12 wtr.	11
Santa Barbara		Sunray Oil Corp's Dominion 2, 330 n 1650 e fr swc Sect 23-9n-33w, Fault block disc. Cat Canyon area.	12-31-48	6686	6393- 6686	Chert	P 285	9
		CALIFORNIA—Oil Field Extension						
Santa Barbara	Cat Canyon	General Pet Corp's Los Flores A-66-21, se¼ Sect 21-9n-33w, nw extension	12-24-48	6333	5435- 6330		P 300	15.2
		ILLINOIS—New Oil Pays						
Christian	Assumption, N.	Nat'l Assoc Pet Co & Continental's Lawrence 4, se se ne 9-13n-1e	1-25-49	1167	1156- 1167	Rosiclare sd; Miss	F 390	
Christian	Assumption, N.	Nat'l Assoc Pet Co. & Continental's Lawrence 5, nw se se 9-13n-1e	1-11-49	1066	1060- 1065	Bethel sd; Miss	P 38	
Gallatin	NewHaven, W.	Yingling's Stoffleth 4, se sw nw 34-7s-10e	1-11-49	2737	2558- 2573	Cypress sd; Miss	P 48; 60 wtr.	
		ILLINOIS—Oil Field Extensions						
Clay	Stanford	Johnson & Canfield's Nodaker 1, (OWWO) ne sw sw 27-3n-7e, 1 mi w extension	1-11-49	3124	2702- 2716	Cypress sd; Miss	P 20; 40 wtr	
Wabash	Maud, N.	C. E. Skiles' Ewald Heirs 1, sw se nw 5-2s-13w, ¾ mi sw extension	1-25-49	2594	2580- 2592	Bethel sd; Miss	P 103	
		INDIANA—New Oil Fields						
Gibson		Kirk D. Holland's Dora Whiting 1, 330 fr nl 116 fr wl Mil Don No. 100, 2-1s-10w, s of Hazelton pl.	1- 4-49	1770	1753- 1768	McClosky sd; Miss	P 40	
Gibson		Superior Oil Co's Joseph Kolb 1, nw se sw 22-1s-10w	1-28-49	2032	1874- 1878	McClosky sd; L Miss	P 57	
Posey		Ashland-Coy Oil Co's Wm. Cullinan 1, nw se sw 23-7s-14w	1-14-49	2800	2650- 2728	McClosky sd; Miss	P 35	
Sullivan		A. S. Reed's G. L. Bolinger et al 1, ne ne ne 19-9n-9w	1-14-49	2229	2089- 2156	Devonian sd; Devo	P 60	
Vigo		Kuykendall Drlg Co's H. McIntosh 1, nw nw sw 24-11n-8w	1-14-49	1720	1621- 1640	Devonian sd; Devo	P 58; 300 wtr	
		KANSAS—New Oil Fields						
Barton	Sunny Valley	Bay Petroleum Corp's Schartz 1, sw sw se 7-20s-12w, 5 mi w Silica pl.	1- 2-49	3433	3230- 3234	Lansing-KC li; Penn	P 302	
Butler	Parsley	Rex and Morris' Parsley 1, nw se ne 3-28s-3e, 1¼ mi w Allen pl.	1-28-49	2704	2695- 2700	Mississippi sd; Miss	P 45	45
Graham	Morlan	Derby Oil Co & Peel Drlg Co's Lewis 1, ne ne nw 23-10s-21w, 5 mi s Morel pl.	1- 1-49	3784	3777- 3781	Arbuckle li; Ord	P 159	
Pratt	Moore	Deep Rock Oil Corp et al's Young 1, sw sw nw 1-26s-14w, 2 mi w Frisbie pl.	1-28-49	4400	4348- 4370	Simpson sd; Ord	P 40; 10 wtr	37.3
Rooks	Hayden	Heathman-Honaker Drlg Co's Hayden 1, ne ne se 31-8s-19w, 1½ mi w Webster pl.	1-28-49	3517	3513- 3516	Arbuckle li; Ord	P 122	
Stafford		Crown Oil Co's Williams 1, sw sw sw 32-23s-13w, 1½ mi sw St. John pl.	1-28-49	3679	3540-	Lansing sd; Penn	P 779	
		KANSAS—Oil Field Extension						
Rooks	McHale	Petroleum Inc's Ruzicka 1, nw nw sw 17-9s-18w, ½ mi sw extension	1-18-49	3619	3614- 3619	Arbuckle li; Ord	P 50	
		KANSAS—New Gas Field						
Harvey		B & R Drlg Co's Jones 1, csl sw ne 21-23s-3w, 1 mi e of Burrton pl	1-18-49	3363	3260- 3328	Mississippi sd; Miss	2.8 mln.	
		KENTUCKY—New Oil Field						
Henderson	Curdsville, W.	Sohio-Petroleum Co & Chester Oil Co's Shiver Heirs 1, sw se nw 1-O-26, 3 mi se Hebbardsville	1-28-49	1829	1822- 1828	Bethel sd; U Miss	P 60; 71 wtr	
		NORTH LOUISIANA—New Oil Fields						
Webster	Dykesville	Barnsdall Oil Co & Pan-American Prod Co's R. Sykes 1, c nw nw 1-22n-9w, 2½ mi sw Haynesville fld.	1-10-49	11592	5654- 5698	Pettit li; L Cre	F 204; ¼"	47.6
		NORTH LOUISIANA—New Distillate Field						
Bienville	Castor	Placid Oil Co's Bienville Lbr Co 1, 3175 fr wl 1850 fr nl Sect 9-14n-7w	1- 3-49	8005	7411- 7425	Travis Peak sd; L Cre	F 15; 4.5 mln; 1/4"	
		NORTH LOUISIANA—New Distillate Pay						
Lincoln	Ruston	Arkansas-Louisiana Gas Co's J. C. Dowling Unit 2, 330 fr s&el ne 30-19n-2w.	1-23-49	8933	8760- 8810	Bodcaw sd; Cre	F 200; 5 mln; 8/16"	53.8
		NORTH LOUISIANA—New Gas Field						
Natchitoches		Chas C. Lowery et al's Tanner 1-A, 50 fr wl 324 fr sl nw 18-10n-10w, 1½ mi s Wallace.	2- 4-49	3347	3180- 3190	Paluxy sd; L Cre	15.6 mln; open	
		SOUTH LOUISIANA—New Oil Fields						
Point Coupee	Fordoche	The Texas Co's Joseph Oscar Long et al 1, 660 s&e fr nwc Sect 29-6s-8e, 1 mi ne Lottie	1- 2-49	10280	8282- 8290		F 332; 8/64"	34.6
St. Martin	Duck Lake	Humble O&R Co's Atchafalaya Ld Co 1, Sect 1-15s-11e, s side of Duck Lake & 4 mi sw West Lake Verrett prod.	1- 6-49	12525	11642-11652		F 273; 8/16"	36.2
		SOUTH LOUISIANA—New Distillate Pay						
Jeff Davis	Edna	Irwin & Hudson's The Houssiere Est., Inc. 1 (was Houssiere-Latreille, Inc. 2) nw Sect 6-8s-4w.	1- 3-49	9372	9121- 9124		F 55; 2.5 mln; 8/32"	46
		MICHIGAN—New Oil Field						
Allegan		Basin Oil Co's Noteboom 1, nw sw nw 18-2n-11w, Martin Twp.	1-11-49	1618	1617- 1618	Traverse sd; Devo	P 18	
		MICHIGAN—Oil Field Extensions						
Van Buren	Coffee Lake	George F. Lister's Rogustad 1, nw nw sw 18-1s-15w, ¾ mi w extension	1-28-49	1131	1128- 1131	Traverse sd; Devo	P 240	
Van Buren	Lacota	Basin Oil Co & Swan-King Oil Co's Kraus 1, se ne se 9-1s-16w, 1 mi w extension.	1-21-49	1063	1061- 1063	Traverse sd; Devo	F 100	
		NEW MEXICO—New Oil Pay						
Lea	Penrose-Skelly	Skelly Oil Co's Sime 2-D, s½ se nw 3-23s-37e	1- 1-49	6620	6402- 6620	Drinkard sd; Perm	P 74; 24 wtr	39.5
		OKLAHOMA—New Oil Fields						
Carter	Hewitt, NW	Continental Oil Co's Head 1, se se se 6-4s-2w	1-14-49	7440	2920- 2960	Deese sd; Penn	F 155	28
Grant	Rich Valley	Mid-Continent & Viersen-Cochran's Vollmer 1, ne ne ne 1-25n-5w	1-13-49	5848	5817- 5829	1st Wilcox sd; Ord	F 1200; ½"	45
Lincoln		Foster Drlg Co's Deacon 1, nw nw sw 25-17n-5e	1-31-49	3430	3418- 3430	Bartlesville sd; Penn	P 45	40.6
Payne		The Texas Co's State School Land "J" 1, ne ne ne 36-19n-3e, 2 mi s Council Creek, SW fld.	1-31-49	3767	3754- 3767	Red Fork sd; Penn	F 118; ¼"	
Pottawatomie		Cities Service Oil Co's Fleming 1, nw sw sw 31-9n-3e	1-13-49	5108	4966- 4976	Hunton li; Devo	P 43; 20 wtr	31
		OKLAHOMA—New Oil Pays						
Noble	Polo, SE	Phillips Pet Co's Dayton 2, ne se sw 2-21n-2w	1-10-49	5136	4994- 4999	Misener sd; Miss	F 288; 8/32"	
Okfuskee	Cary	Jergins' Krumme 1, se se ne 32-12n-10e	1-20-49	3067	2557- 2566	Booch sd; Penn	F 3; 3.3 mln; 1/4"	
		TENNESSEE—New Oil Field						
Sumner	"Nubia"	W. B. Dye's Mary Scott 1, nw ne se Sect 8 B 38e	Jan 1949	500				
		TEXAS—District1 (SOUTH CENTRAL) New Oil Field						
Frio		Magnolia Pet Co's Ella C. Wolfe 1, 330 fr sel 1100 fr nel W. P. Wolfe Sur, 5½ mi ne Pearsall.	1- 4-49	3724	3704- 3724	Navarro sd; U Cre	P 5; 20 wtr	
		TEXAS—District 2 (MIDDLE GULF) New Oil Fields						
Live Oak		James G. McCarrick Tr's Ida A. Richey et al 1, 2450 fr swl 200 fr nwl P. Salinas Sur 1 mi w Fort Merrill fld.	1- 5-49	4775	4538- 4544		F 110; 8/64"	47
		TEXAS—District 2 (MIDDLE GULF) New Distillate Fields						
Bee		Sun Oil Co's Ehler-Wolters Unit 1, 330 fr seLswl V. M. Ehlers Tr 1½ mi sw Yoward fld.	1- 5-49	7696	7548- 7558		F 35; 1.6 mln; 8/16"	52.6
Goliad		W. L. Goldston's J. R. & A. D. Willbern 1, 480 fr el 660 fr sl 80-ac lse, Victor Blanco Gr, 1¼ mi nw Charco.	1- 8-49	9277	8660- 8672		Frogge; 18 mln; open	
Victoria	Mission Valley, W.	Western Natural Gas Co's M. E. Cooley et al 1, 500e of Coleto Creek & 660 fr nwl of Benj. J. White Sur, 7 mi sw mission Valley.	1- 4-49	9082	8895- 8925	Wicox sd; Eoc	F 50; 2.5 mln; 1/4"	
		TEXAS—District 2 (MIDDLE GULF) New Distillate Pays						
Live Oak	Coquat	Western Natural Gas Co's Geo. Maguglin 1, 1980 fr nwl 1700 fr swl E. Votaw Sur 3000 e of prod.	1- 1-49	8363	7986- 8000	Mackhank sd; Eoc	F 81; 4.1 mln; 1/4"	
		TEXAS—District 2 (MIDDLE GULF) New Gas Fields						
Calhoun		Quintana Pet Corp's Louise Kubatt et al 1, 350 fr ne&nwl Blk 4, Y. Benavides Gr, 7½ mi w Port Lavaca.	11-15-48	9310	8767- 8791		29 mln; open	55.1
Goliad		Ginther, Warren & Ginther's Sallie Flowers 1, 1020 fr nwl 1075 fr nl 200-ac lse, Andrew Devereux Sur, 1 mi s Goliad.	1- 5-49	5183	4240- 4254		51 mln; open	
		TEXAS—District 3 (UPPER GULF) New Oil Fields						
Brazoria		Hassie Hunt, Tr's H. H. Stowe 1, 660 fr sw&sel of 1056.61-ac lse, B. C. Franklin Lge 2 mi n Old Ocean fld. Flag Pond area.	1-15-49	11030	10691-10697		F 109; 8/64"	53.9
Newton	Hartburg	Texas Gulf Prod Co & Rowan Drlg Co's Morgan et al 1, 1200 fr el 990 fr nl W. B. Ellis Sur, ¼ mi w Hartburg.	1-18-49	8013	7556- 7560	L Frio or Hackberry sd; Olig	F 198; 1/8"	42.6

[1] Character of producing formations abbreviated thus: ch, chalk; dolo, dolomite; li, limestone; sd, sandstone; sh, shale; ser, serpentine; cgl, conglomerate. Ages of formations abbreviated thus: Plio, Pliocene; Mio, Miocene; Olig, Oligocene; Eoc, Eocene; U. Cre, Upper Cretaceous; L. Cre, Lower Cretaceous; Jur, Jurassic; Tri, Triassic; Perm, Permian; Penn, Pennsylvanian; U. Miss, Upper Mississippian; L. Miss, Lower Mississippian; Devo, Devonian; Sil, Silurian; Ord, Ordovician; Cam, Cambrian.

[2] Barrels of oil per day (24 hr. rate), flowing (F), pumping (P), swabbing (Sw), or bailing (B); or million cubic feet of gas daily open flow capacity; size of choke given in inches.

Practical Treatment of Clay Type Drilling Muds

By SAM HARRIS
Petroleum Engineer, Kerr-McGee Oil Industries, Inc.

THE "know-how" control of field muds comes from experience and an understanding of the basic principles of water-base muds. The first prerequisite for mud control is an operating knowledge of each piece of equipment used to test the drilling mud and how to interpret the results obtained. This article is presented as a practical guide for the operating crews in the daily treatment of native clay and bentonite type clay drilling muds.

Best results will be obtained from a drilling mud if a daily treatment is used. When this treatment can be carried on by the drilling crews, the headaches of the service engineer are lessened. The walls of the hole will remain in a better condition due to the proper control of the circulating fluid.

Set rules for mud control cannot be made, as each area presents different problems of control; but it is equally true that many of the problems encountered in drilling operations can be traced directly to the rotary fluid. When the mud is maintained in the best condition for efficient operation at all times these problems are lessened appreciably.

THE CHEMISTRY of drilling muds is an involved subject of colloidal chemistry. This article is presented as a practical guide for field crews in the daily treatment of native clay and bentonite-type clay drilling muds. Application of the suggestions contained in this paper will result in a lessening of circulation problems in rotary drilling.

Viscosity Testing

The Marsh funnel is almost universally used for field testing of the viscosity of drilling muds. The mud should always enter the funnel through the screen. The screen is provided to remove cuttings and debris. Any particle larger than the screen openings may change the viscosity by restricting the orifice of the funnel. The funnel should be filled to the bottom of the screen while the operator stops the tip of the spout with a finger. Using a stop watch, the time in seconds for one quart of the mud to run into the cup is measured. This is recorded as the viscosity of the mud. There are variations in different areas on the amount of mud measured. Some areas use 1000 cubic centimeters out. The amount run out should be recorded, as "1500 cc. in one quart" or "1500 cc. in 1000 cc. out." It should be noted that API Code 29 specifies "1500 cc.'s in one quart out."

The Marsh funnel should be calibrated at least once each tour to eliminate possibility of errors in viscosity measurements due to dented, bent or clogged orifices. To calibrate the Marsh funnel for use with the standard API Method of 1500 cc.'s of clear water at a temperature between 70 and 80° F. and to check the time that it takes for one quart to run out, the funnel should be filled with fresh water which should run out in 26 seconds, plus or minus one-half second. Some of the errors made in viscosity determination with the Marsh funnel are caused by the following:

1. Failure to calibrate the funnel regularly.
2. Failure to keep the funnel clean. The funnel should be thoroughly cleaned of dried mud inside and out. Make sure the spout is clean.
3. Delay in running the viscosity test. The viscosity should be run immediately after the funnel is filled, thus eliminating as much error as possible caused by gelling of the mud. Run the viscosity immediately after taking the sample from the system.
4. Improper sampling. The sample should be taken from a point in the system where the mud is receiving the maximum agitation. The most satisfactory point at which to obtain the sample is at the flow line discharge, or immediately under the shale shaker screen.
5. Incorrect timing. The use of a stop watch is essential.
6. Failure to screen the mud into the funnel.

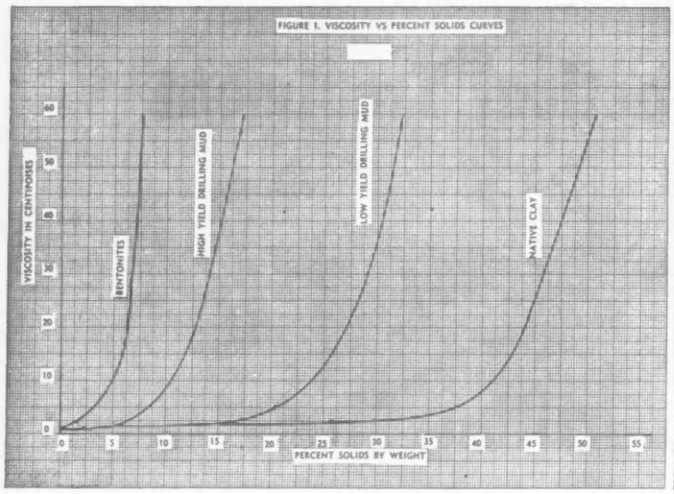
Viscosity Control

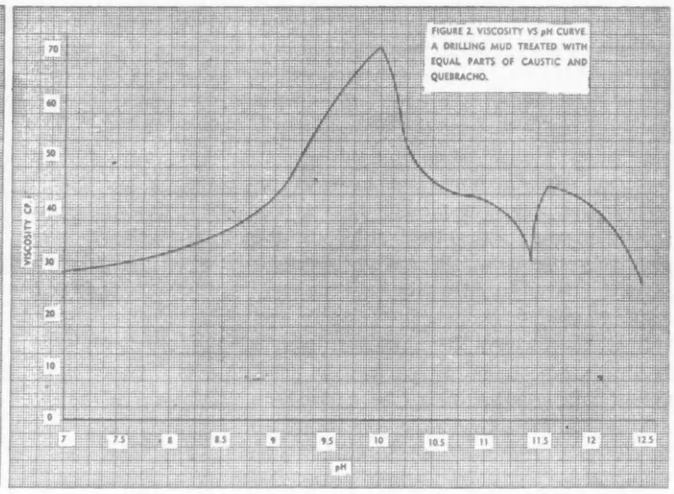
There are several factors which may change the viscosity of a drilling fluid.

1. *Solid content:* Since mud is a two-phase system, i.e., liquid and solids, the concentration of the solids in the liquid phase has a direct bearing on the viscosity of the drilling mud. The solids may be bentonite type clay particles, sand and shale particles and other solids picked up from the formation, and/or weighting materials which may have been added to the mud. For a given viscosity, the higher the colloidal content of the solid, the lower the percent of solids. This is shown by Figure 1.

The curves in Figure 1 are average curves. Thus, increased viscosity of a drilling mud may be caused by too high a solid content. The viscosity can be corrected by dilution with water when this is the cause.

2. *Colloidal dispersion:* The degree to which a solid particle has swelled upon contact with water will affect the viscosity. Those solids having an affinity for water tend to increase the viscosity more readily than those which do not. Thus, as drilling is progressing, part of the cuttings are apparently dissolving in the drilling mud and the viscosity increases. This may indicate that colloidal





type clays have been penetrated by the drill bit. The condition may be corrected by the proper balance of water and chemical treatment.

3. *Contamination:* The viscosity of a drilling mud is affected by any of the several types of chemical contaminants. The most common types are calcium and magnesium contamination, sulfate contamination, and salt contamination. Occasionally carbonates may be picked up from limestones and give some trouble, but this is not common.

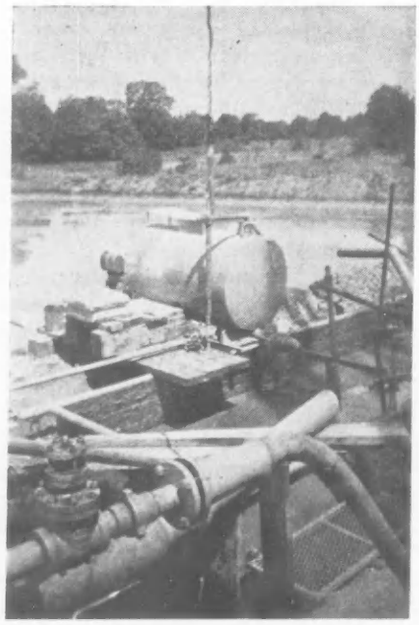
A. Calcium contamination: This type of contamination is usually encountered where sections of gypsum or anhydrite are drilled, or when cement has gotten into the mud. It is evidenced by increased viscosities and gel strengths. The pH which is discussed later in this paper will be higher when the contamination is caused by cement due to the hydroxide formed by the cement. Thus, when treating out cement contamination, the treating chemical must lower the pH along with the removal of the calcium. Some of the commonly used chemicals for this are sodium bicarbonate, sodium acid pyrophosphate, monosodium phosphate, complex phosphate, and weak caustic and strong quebracho solutions. They reduce the pH along with the reduction in viscosity.

When contamination is caused by calcium from gypsum or anhydrite formations, the viscosity and gel strengths increase, but the pH does not necessarily increase. A very effective treatment for this type of calcium contamination is the use of soda ash (sodium carbonate) and anhydrox (barium carbonate). The amounts of treating chemical required will be determined by the amount of contamination. Quebracho is usually used with the soda ash for gel strength control.

When a drilling mud containing bentonite becomes contaminated with calcium, the sodium ion moves off and the calcium ion goes on to form calcium bentonite, which does not have the affinity for water that the sodium bentonite has. Thus, when the conventional test for calcium is made on the filtrate of the mud, the calcium shown to be present in the filtrate does not necessarily show how much there may be in the mud in the form of calcium bentonite. Occasionally, calcium contamination may be present, and to the average worker is not apparent until the reaction of the mud shows it to be present.

B. Sulfate contamination: Sulfates are usually found in muds that have been treated for calcium or magnesium sulfate contamination with soda ash. Thus, the sulfate is left in the mud as salt. By treating with barium carbonate, the sulfate may be taken out as barium sulfate which is common weighting material.

C. Salt contamination: Evidence of salt contamination is noted when concentrations of 5000 parts per million or more are in the mud. Muds may be satisfactorily handled as bentonite type muds with this concentration. As the concentration approaches 10,000 parts per million, it becomes progressively harder to hold at the proper viscosity and maintain the water loss. Above 10,000 parts per million of salt (NaCl), it is usually necessary to convert to one of the special muds. The usual control for salt contamination is increasing weight to stop salt entry into the mud if the source is a salt flow, and dilution of the concentration with good mixing water, addition of colloidal clay and treatment with mixtures of caustic and quebracho for additional control of viscosity and gel strengths.



Suction pit and the gel hydrator used to prehydrate gel and weighting materials for addition to the system.

Gel Strength Test

The Stormer viscosimeter is almost universally used for gel strength test. They are not usually kept on a drilling rig, but are used consistently by the mud engineer. The initial gel strength test is made by filling the cup of the viscosimeter to within one-eighth inch of the top, placing the cup in its holder, and raising it until the enlarged section of the rotating spindle is completely covered with the drilling mud. The mud is then agitated by rotating the ratchet wheel on top of the gear box. The brake is set after agitation and then immediately released.

The required weight in grams placed on the string to give the rotating spindle one-fourth to one-half turn before it stops is the initial gel strength in grams. After the initial gel strength test has been made the mud is allowed to remain undisturbed for ten minutes. After ten minutes the number of grams added to the string on the ratchet wheel to start rotation of the spindle in the mud is the ten-minute gel strength.

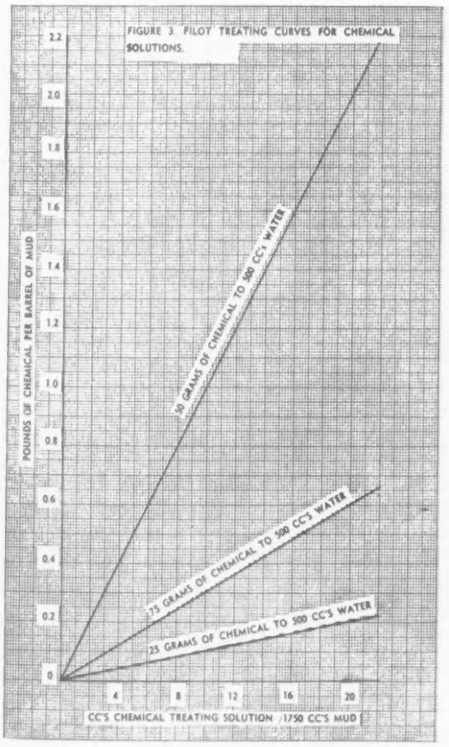
Gel Strength Control

The gel strength of a native clay or bentonite type drilling mud is usually an indication of the degree of dispersion of the individual clay particles. Consistent

with other properties of the drilling mud, the best operating characteristics for gel strength in native clay or bentonite type muds is to maintain the ten-minute gel strength within a range of approximately ten to 20 grams. The gel strengths may be controlled by addition of colloidal clays to increase gel strength, and caustic and quebracho mixes or some of the phosphates to reduce gel strengths. Control of gel strengths is necessary as high gel strengths usually cause entrainment of sand and occasionally gas in the drilling mud as well as excessive pump pressure to break circulation.

The density of a drilling fluid is the weight per unit volume; that is, the weight of one gallon of the mud in pounds per gallon or weight in pounds per cubic foot of mud. The API committee on mud testing recommends that the density of mud be expressed in pounds per square inch per 100 feet of depth of mud in the hole. There are two commonly used instruments for measuring the mud density. They are the hydrometer and the mud balances.

The hydrometer is a hollow cylindrical tube with a shot chamber at the top and a detachable plastic cup on the bottom. The instrument is usually supplied with a metal barrel, containing a sliding wind guard, for suspending the hydrometer in water. The hydrometer is calibrated by filling the plastic cup with clean water at approximately 70° F., attaching it to the hydrometer and suspending the unit in clean water at approximately 70° F. Shot is added to or removed from the shot chamber in the top of the hydrometer until the unit floats at the etched calibration mark for water.



The mud density or weight is determined by filling the plastic cup with mud which has been screened to remove the cuttings, attaching it to the bottom of the hydrometer, and suspending the unit in clear water at approximately 70° F. The density or weight in pounds per gallon or pounds per square inch per 100 feet of depth is read on the calibrated scale.

This instrument must be properly maintained for accurate results. The unit must be kept clean of all dried and caked mud. The water in which the hydrometer is suspended should be changed each time a weight determination is made. The hydrometer should be calibrated each tour.

The mud balance is a more practical instrument for determining mud density or weight at the drilling rig. The instrument consists of a cup with a machined cover and a balance arm with a metal rider. The cup is filled with mud. The cover is placed on, running the excess mud out the hole in the top of the cover. The mud is cleaned from the outside of the cup. The knife edges of the bearings on the arm are placed on the fulcrum, and the sliding rider is moved out until the bubble in the level is exact center. The mud weight is then read on the scale of the balance arm. The mud weight may be read in pounds per gallon or in pounds per square inch per 100 foot depth as both scales are provided on the balance arm.

To calibrate the mud balance, fill the cup with clear water, place the lid on and dry off excess water which is displaced by the lid. Set the rider at the calibrated mark for water and check the level bubble. If the bubble is not at the exact center, add or remove shot from the shot chamber at the end of the balance arm until the bubble is level. This instrument should be kept clean at all times for accurate results.

Mud Density Control

The mud density must be controlled within practical limits. The existing conditions of the formation being penetrated, the reservoir pressure and the rock pressure will determine the density of the drilling mud.

Barium sulfate is almost universally used for increasing mud density. It has a specific gravity of approximately 4.2 to 4.3. A convenient formula for calculating the amount of barites to add to 100 barrels of mud to raise the weight from one amount to any desired amount is as follows:

$$X = \frac{1505\ (W_2 - W_1)}{35.8 - W_2}$$

X = Sacks of barium sulfate per 100 barrels of mud
W_1 = Present weight
W_2 = Desired weight

Discharge pit showing the baffle arrangement, the mud guns, the shale shaker, and a roughneck dissolving caustic and quebracho prior to adding them to the system.

The tendency of the average operator is to carry the mud density as low as possible and still maintain a safety factor of differential pressure. Many times trouble from caving, tight hole, etc., can be eliminated by increasing the mud density.

Sand Content

There are two commonly used methods of determining the sand content of drilling muds. They are the elutriation method and the screen and funnel method. The screen and funnel method is the most practical for the drilling rig and will be the only one discussed. The apparatus for this test consists of a special No. 200 mesh sieve 2½ inches in diameter inside a collar upon either end of which fits a small funnel. To be used with the screen and funnel is either a 100 cc. calibrated centrifuge tube or a 250 cc. calibrated elutriation tube.

The most satisfactory procedure for using the screen and funnel is to measure a definite volume of mud into either the centrifuge tube or elutriation tube. These tubes contain a graduation mark indicating the level to which the tube should be filled with mud and a graduation showing the amount of dilution with clean water. Having filled the tube with the prescribed volume of mud and having diluted it with water, place the thumb over the mouth and thoroughly shake the contents. With the funnel attached to sieve, pour the diluted mud through the sieve and rinse with clean water until the wash coming through the sieve is clear. The sieve should be wet prior to pouring the diluted mud through it. Remove the funnel from the bottom of the sieve and place it on top. Place the tube opening over the funnel end and invert the unit. Wash the con-

tents on the screen into the tube with clear water, being careful not to overflow the tube with water. Allow the sand to settle and read the percent as shown on the calibrations.

The sand in a drilling mud offers no benefits. It is abrasive to all the equipment which it contacts. It should be held to a minimum. Standard practices are to hold it to limits of 1 to 2 percent of total volume of mud.

Proper control of gel strengths and viscosity of the drilling mud greatly aids in the reduction of sand content. An efficient arrangement of baffles in the pits and the use of a shale shaker will facilitate the removal of sand from the drilling mud.

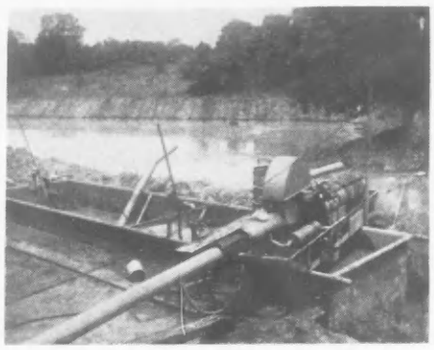
The Filtration Test

The filtration test of a drilling mud is a relative measure of the wall building properties of the mud and the loss of the liquid phase of the mud to the formations.

The filter press consists of a container assembly held in place by a screw clasp in a bolted frame. The container assembly consists of a cylinder, bottom and top cap, two rubber gaskets, a screen, and the filter paper. The filtration test is made by assembling the container, being sure the filter paper is in place on top of the screen. Fill the container to within one inch of the top with the mud to be tested. Place the container in the filter press frame and tighten the cap down by means of the screen clamp until the container will hold pressure without leaking. Place the graduated receiver under the container and apply the pressure by means of the regulator until the gauge shows 100 pounds. A variance of five pounds either way does not affect the filtration test. Allow the test to run 30 minutes from the time the pressure is applied. The volume of filtrate in cc.'s coming through the filter paper into the graduated container is read as the fluid loss in cc.'s.

Filtration Control

An understanding of the principles of cake deposition and filtration loss clarifies the interpretation of the test. A drilling mud consists of two phases, liquid and solids. The solids consist of various sized particles. When such a fluid is placed in a container having a porous opening such as the filter paper on the bottom of the filter press, or the porous walls of the hole, and pressure is applied to the mud container, the mixture of fluid and solids attempts to leave the container through the porous openings. Since the liquid is a true fluid, it is able to pass through the minute openings of the porous media; thus, the solid particles, some of which are larger



Discharge pit and shale shaker assembly.

than the openings in the media, are left behind on its face. As more fluid passes through the porous media, more particles are deposited. The particles, being of different size, gradually form an impervious sheath. The finer particles fill the voids left by the larger particles. When this takes place, the fluid passing through is gradually restricted. When the maximum density is obtained in the filter cake, the fluid passing through is at a minimum. Thus, high fluid losses on the filter press indicate improper distribution of particles. This may be caused by insufficiently dispersed bentonite or an unbalanced condition of clays and water. Thus, the reduction of fluid loss is accomplished by treating the mud to aid in connecting the distribution of the particles. By chemical treatment the clay particles may be spread further apart, giving more available minute particles to fill the voids left by the large particles. In compounding drilling muds the use of some high yield clays with the bentonites greatly aids in the fluid loss reduction.

In some instances, the addition of water to mud will reduce the fluid loss. The average fluid loss of a good water base mud should be 6 to 12 cc.'c in 30 minutes.

pH Factor

The pH is a measure of the alkalinity or the acidity of a fluid. Double distilled water has a pH of seven. From seven to 14 is alkaline and from seven to zero is acid.

The pH is usually determined by the mud service engineer on a "Beckman" pH meter. Since this is essentially a laboratory instrument and is not practical for maintenance on the drilling rig, the method of determining pH on the drilling rig discussed herein is by the paper strip method. The paper strip method is not as accurate as the pH meter.

To determine the pH of the drilling mud, a strip of the paper one to 1½ inches long should be placed on the surface of the mud after the mud is stirred. Leave the paper on the mud until it has become saturated with the fluid. The paper, having been wetted, is removed, allowed to remain undisturbed two to three minutes on a piece of wood or some dry material, then compared with the color chart to obtain the approximate pH value. The filtrate of the drilling mud is checked for pH by placing the end of a strip of the paper in a small portion of the filtrate allowing the paper to dry a few minutes and then comparing with the color chart.

The pH control of a drilling mud is essential for best results. Figure 2 is an approximate curve and shows mud treated with caustic and quebracho solution.

This shows that the high viscosities come at pH of ten and again at about 11.6. This will vary with types of clays and muds. This shows that for best control of the mud, the pH should be maintained on a low point of the curve, that is 7.2 to nine or around 11.4 to 11.45.

The pH may be controlled by the proper selection of chemicals. A list of the common mud treating chemicals, the rig floor names, chemical names and pH when made up in 10 percent solutions of fresh water are given in Table I. These are found on page 16 of the fifth edition of "Principles of Drilling Mud Control," University of Texas, Extension Division.

TABLE 1

Rig Names	Chemical Names	pH
Sapp	Sodium Aid Pyrophosphate	4.28
Quebracho (tannic acid)	Digallic Acid	5.78
Calgon	Sodium Hexametaphosphate	5.80
Barium	Sodium Hexametaphosphate	5.80
Valosa Special Phosphate	Sodium Hexametaphosphate	5.80
Quadrofos	Sodium Tetra Phosphate	7.00
Bentonite	Bentonite	7.00
Barytes	Barium Sulfate	7.00
Oilfos	Sodium Tetra Phosphate	7.00
Bicarb	Sodium Bicarbonate	8.20
TSPP	Tetra Sodium Pyrophosphate	9.70
Soda Ash	Sodium Carbonate	11.20
Caustic Soda (Lye)	Sodium Hydroxide	14.00

The chemicals should be added to a system in a water solution for most efficient results. Usually 50 pounds to the barrel of water is mixed and then added in about a ¼ inch stream or in one circulation. The best method for the selection of chemicals is by pilot testing. A section of this article is devoted to pilot testing on the drilling rig.

Lost Circulation

In many areas high permeability sands, cracks and crevices are encountered in the formations drilled. These are large enough to allow entry of mud into them. When this condition exists, the proper removal of cuttings from the hole is not accomplished and if not corrected immediately the circulating medium reduces in volume until there is not sufficient mud to circulate. All types of bulky ma-

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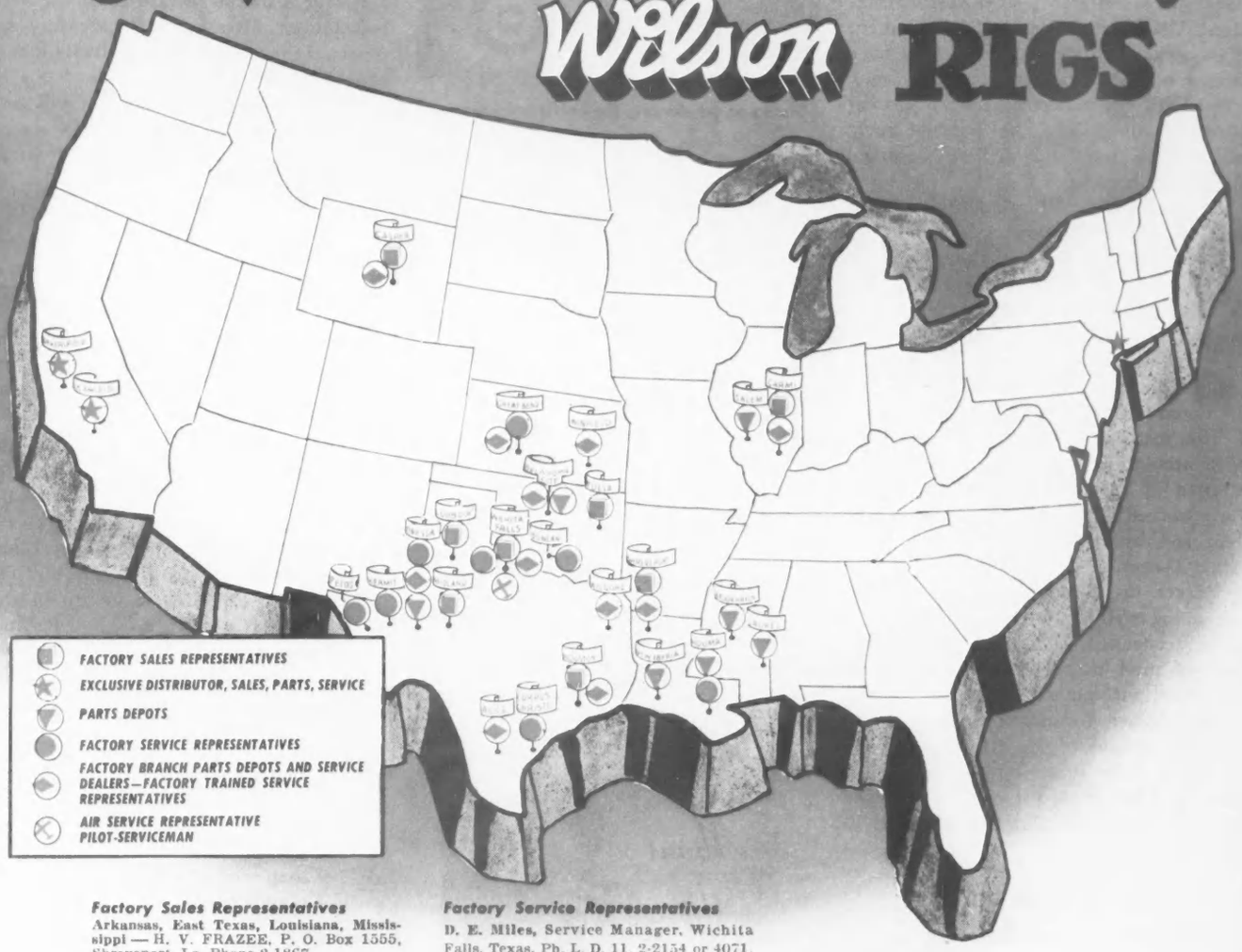
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terials have been used to restore lost circulation. Common among these are shredded red wood, shredded cellophane, shredded chicken feathers, hay, paper sacks, cotton seed hulls, and cotton burrs. Some of the commercially available oil base drilling muds have been used successfully to restore lost circulation. When all of these fail, cement slurrys are usually used. There have been reported instances of caverns being filled with crushed rock, then a cement slurry pumped into the crushed rock, allowed to set, and drilling resumed through the mass.

In areas where loss of the drilling fluid to the formation occurs, a close check should be kept on the volume of mud in the system. A convenient gauge is to suspend a block of wood at the surface of the mud by means of a piece of rope at some point in the pits. A rapid lowering of the mud in the pit can be noted by checking the gauge.

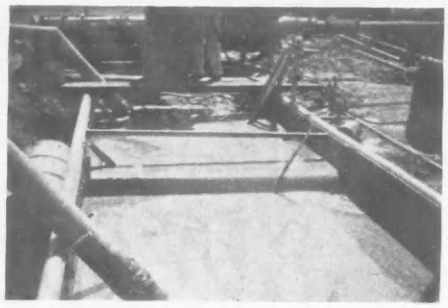
The materials used for restoring the lost circulation are usually added at the suction of the mud pumps. After they have served their purpose they may be removed by running the mud over a shale shaker.

Where there is evidence of lost returns the weight of the mud should be closely checked. In some instances the loss of mud to the formation may be corrected without using the foreign materials. When formation pressures permit, the weight of the drilling fluid can be reduced by watering and if a shale shaker is being used it can be bypassed to allow some of the screened solids to re-circulate.

Analysis of the Filtrates

The chemical composition of the filtrate of the drilling mud tells much about the condition of the mud. The filtrate should be analyzed for salt, calcium, sulfate, and total alkalinity. The test chemical usually can be secured in the proper concentration from any of the oil field equipment supply stores. A good reference for mixing the chemicals and the procedure for making each test on the filtrate is found in the handbook published by the University of Texas, Division of Extension, "Principles of Drilling Mud Control."

Briefly, the salt test is made as follows: A measured amount of filtrate from the filtration test is placed in a clean porcelain dish or clear bottle, two to ten cc. being sufficient. Add a few drops of potassium chromate indicator, then add standard silver nitrate solution a little at a time, stirring or shaking the sample after each addition, until the sample reaches a salmon pink color and remains at that color. This is the end point of the titration. The percent salt is then calculated as follows:



Discharge pit showing the baffle arrangement

$$\frac{\text{cc.'s of silver nitrate}}{\text{cc.'s of filtrate used}} = \text{percent salt}$$

Percent salt $\times$ 10,000 = salt content in parts per million. The standard silver nitrate solution used has a strength of 1 cc. = .01 gr. salt.

The calcium test is made on a few cc.'s of the filtrate by adding a few drops of ammonium oxalate solution. A cloudy precipitate indicates the presence of the calcium ion. This test does not give the amount of calcium present in the filtrate. Some mud engineers use a calibrated centrifuge and determine the calcium present in parts per million. When the test for calcium shows any calcium present, a treatment, adjusted accordingly, to the degree of calcium contamination, should be started.

The test for sulfate is conducted in the same manner as for calcium except a few drops of barium chloride solution are used to precipitate the sulfate ion. The usual treatment for sulfate is the addition of barium carbonate to the drilling mud.

The test for the alkalinity is made on a few cc.'s of the filtrate from the wall building or filtration test. Measure by pipette four to ten cc.'s of filtrate into a clear bottle, add four or five drops of phenolphthalein indicator. This will give a pink color. Add drop by drop a standard acid solution until the color disappears (use nitric or hydrochloric in N/10 solution). The percent alkalinity is calculated as follows:

$$\text{Percent alkalinity} = \frac{\text{cc. acid added} \times 0.4}{\text{cc. filtrate used}}$$

The alkalinity is a measure of the presence of certain salts in the drilling mud. They are usually carbonates, bicarbonates or hydrates.

Another test commonly used by the mud service engineer and practical for use by crews on a drilling rig is the soap test for hardness. This test is a measure of the calcium and magnesium salts in the filtrate or mixing water. The sodium salt will also show up in this test. This test is made by adding standard soap solution to several cc.'s of the filtrate or mixing water until a stable lather is formed when the mixture is shaken vigorously. This test requires practice by the one making the test as a false end point sometimes is noted in the test. The hardness is calculated as follows:

$$\frac{\text{cc.'s of soap used} \times 1000}{\text{cc.'s of sample used}} = \text{Hardness in parts per million}$$

To determine the amount of chemicals necessary to treat a mud system, the best method for the operating crews is by pilot testing. The sample of mud should be thoroughly stirred after the addition of chemicals. A good mixer for use on the rig is a one-fourth-inch electric hand drill with a bent one-fourth-inch welding rod as a paddle. Any type of container which will hold at least one gallon of fluid is sufficient.

Practical Method for Pilot Testing Drilling Muds at the Well

One gram of dry chemical in 350 cc.'s of drilling mud is equivalent to one pound of dry chemical in one barrel of drilling mud. Thus, when making a pilot test, use either 350 cc.'s of drilling mud or some multiple of 350 cc.'s. If it is necessary to check Marsh funnel viscosities, use 1750 cc.'s of drilling mud; this is five times 350 cc.'s. Thus, the number of grams of chemicals it takes to give the desired results will be di-

About the Author

SAM HARRIS graduated from the University of Oklahoma in 1942 with a B.S. Degree in Petroleum Engineering and then joined Anderson-Pritchard Oil Corporation research and development laboratories at Cyril, Okla. In 1945 he resigned to join Halliburton Oil Well Cementing Company at Duncan Okla., and after six months as a plastic development engineer was transferred to the Mud department. Harris has had wide experience in drilling mud practice in the Louisiana Gulf Coast, in South and West Texas, Oklahoma, Colorado and Wyoming. He has been with Kerr-McGee Oil Industries, Inc., since early in 1948.

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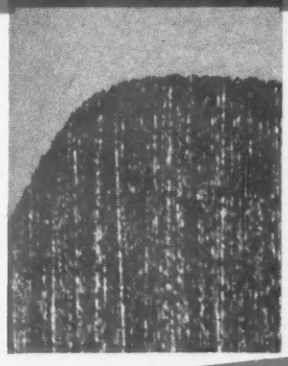

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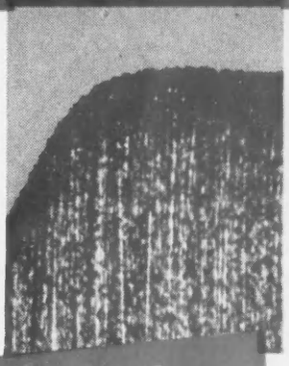
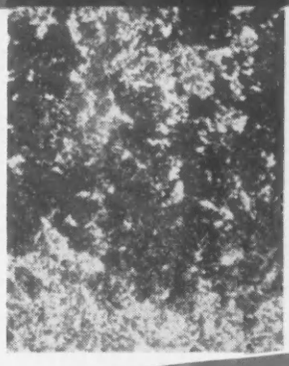


Non-uniform structure that causes galling and failures



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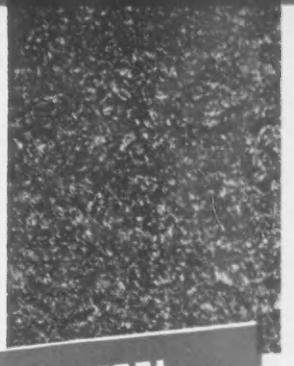

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vided by five to get the pounds of dry chemical per barrel of mud.

EXAMPLE: Use 1750 cc.'s mud. Suppose it takes one gram of caustic and one gram of quebracho to give the desired reduction in fluid loss, gel strengths and viscosity; one divided by five equals 0.2 grams have been used in 350 cc.'s sample. Thus, 0.2 pound of caustic and 0.2 pound of quebracho are required per barrel of mud to treat the system. Therefore 300 times 0.2 equals 60 pounds of caustic and 0.2 times 300 equals 60 pounds of quebracho which will be the total amount required for a 300-barrel system. It is usually faster and better to use the treating chemical in a water solution. Here are instructions on how to mix any desired chemical and to calculate the amount of dry chemical contained in one cc. of the chemical solution: EXAMPLE A:

1. Weigh out 75 grams of quebracho and 25 grams of caustic soda and place these in a bottle which has previously been calibrated to a 500 cc. volume mark. Add water up to the 500 cc. calibration mark and allow the chemicals to dissolve. (To calculate the amount of solid chemical per one cc. of the solution: 75 divided by 500 equals 0.15 grams of solid quebracho for one cc. of solution and 25 divided by 500 equals 0.05 grams of solid caustic for each one cc. of solution.) Therefore, if 10 cc.'s of the solution are added to 1750 cc.'s of mud, there has been added 10 times 0.15 which equals 1.5 grams of solid quebracho, and 10 times .05 which equals 0.5 gram of solid caustic. (To determine the pounds per barrel: 1.5 divided by five equals 0.3 pound per barrel quebracho and 0.5 divided by five equals 0.1 pound per barrel of caustic.) These are the required amounts of chemicals for each barrel of mud in the system.

2. Fifty grams of caustic and 50 grams of quebracho diluted as indicated would contain 50 divided by 500 equalling 0.1 gram of each chemical per one cc. of solution. Thus, 10 cc.'s of this solution added to 1750 cc.'s of mud result in 10 times 0.1 which equals one gram of solid caustic and one gram of solid quebracho in this volume of mud. Therefore, one gram divided by five will equal 0.2 pound per barrel in the mud in the system.

Figure 3 is a graphic presentation of Example A, parts 1 and 2.

No calculations are necessary when this graph is used to determine the pounds of chemicals per barrel of mud. As an illustration of the application of this graph, suppose 12 cc.'s of chemical mixture as prepared in Example A, part 1, is added to 1750 cc.'s of drilling mud. Find 12 cc.'s on the abscissa of the curve, follow this up to the curve marked 25 grams of chemical to 500 cc.'s of water and from the intersection with this curve follow across to the ordinate and read 0.12 pounds of chemical per barrel of mud. The result would be 0.12 pounds of caustic soda per barrel of mud since there were 25 grams of caustic soda in the prepared treating solution. Since there were 75 grams of quebracho dissolved in the prepared treating solution, the procedure for determining the pounds of quebracho per barrel of mud would be to follow the 12 cc.'s line up to the curve, 75 grams of chemical to 500 cc.'s of water. From the intersection with this curve read across on the ordinate 0.36 pounds of chemical per barrel of mud. This would be 0.36 pounds of quebracho per barrel of mud.

If 12 cc.'s of the chemical solution was used, as prepared in Example A, part 2, then read: from the intersection of the curve marked 50 grams of chemical to 500 cc.'s of water, on the ordinate 1.2 pounds of chemical per barrel of mud. Since there are 50 grams of each chemical in the prepared solution then 1.2 pounds of caustic soda and 1.2 pounds of quebracho would be required for each barrel of drilling mud.

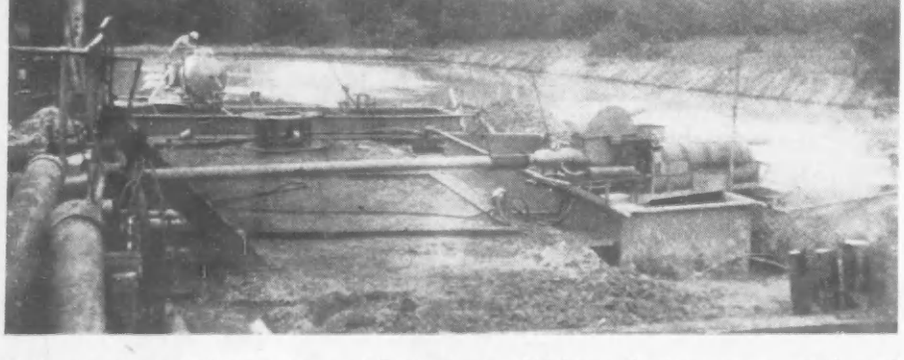
This graph may be used for any of the solutions shown herein or that may be prepared as recommended.

Any of the mud treating chemicals can be made up as given above and used for pilot testing.

Some of the most commonly used chemicals in pilot testing:

1. 75 grams of quebracho
   25 grams of caustic
   Diluted to 500 cc.'s with water
   This solution contains for each 1 cc.
   .15 grams of quebracho
   .05 grams of caustic
2. 50 grams of quebracho
   50 grams of caustic
   Diluted to 500 cc.'s with water
   This solution contains for each 1 cc.
   .1 gram quebracho
   .1 gram caustic
3. 100 grams of soda ash
   Diluted to 500 cc.'s with water
   This solution contains for each 1 cc.
   .2 grams of soda ash
4. 100 grams of sodium bicarbonate
   Diluted to 500 cc.'s with water
   This solution contains for each 1 cc.
   .2 grams of sodium bicarbonate
5. 100 grams of SAPP (Sodium Acid Pyro Phosphate)
   Diluted to 500 cc.'s with water
   This solution contains for each 1 cc.
   .2 grams of SAPP
6. 50 grams of soda ash
   50 grams of quebracho
   Diluted to 500 cc.'s with water
   This solution contains for each 1 cc.
   .1 gram quebracho
   .1 gram caustic
7. 50 grams of soda ash
   50 grams of quebracho
   25 grams of caustic
   Diluted to 500 cc.'s with water
   This solution contains for each 1 cc.
   .1 gram soda ash
   .1 gram quebracho
   .05 gram caustic

Although general in scope, this article is presented in order to enable drilling crews and operators to obtain a greater understanding of drilling mud control problems and for those who are interested in a more complete discussion the writer recommends that they consult the references listed below.



Mud system in the Golden Trend area of Garvin County, Oklahoma, showing arrangement of metal pits for proper control of water base muds and 20-barrel tank for prehydrating clays and bentonites.

ACKNOWLEDGMENTS

Author is indebted to the management of the Refining Division, Kerr-McGee Oil Industries, Inc., for permission to publish this article. Photographs are through courtesy of B & B Drilling Co., Pauls Valley, Okla.

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Multi-Stage Cementing

In the Permian Basin

By R. D. McBRIAN
Baker Oil Tools, Inc.

FORMATION characteristics in many of the fields of West Texas and Southeast New Mexico make some type of multi-stage cementing necessary if the various oil or gas bearing zones are to be separated and conserved and the well casing protected from corrosive fluids.

Generally speaking, all fluids found are trapped in porous, cavernous or fractured limestone or fractured chert. These formations break down and take fluid readily when bottom hole pressure is overbalanced by a column of heavy mud or cement slurry. In some of the deeper fields the well bore may penetrate as many as eight such zones capable of producing oil or gas in commercial quantities. Furthermore, a section of almost pure salt underlies the entire area at shallow depth. Even though salt saturated muds are used in drilling, this section dissolves enough to develop large cavities.

These conditions often prevent raising cement slurry in one stage from the shoe to the high level indicated as good practice. When this is attempted any one of several zones may break down and returns may be lost, partially or completely. The cement does not reach the desired level, shallower fluid bearing zones are not properly isolated, and casing is incompletely protected. In addition, the producing ability of some important zone may be permanently or temporarily impaired by intrusion of cement slurry.

Protection Important

The importance of protecting well casing from corrosive fluids is beginning to be recognized, as many operators are forced to expensive repairs on casing set, but not completely cemented, through shallow oil, gas, salt or water bearing zones. Practically all oils and gases and some formation waters of the area contain hydrogen sulfide; other waters may carry salt in considerable concentration. Each is corrosive in itself but combinations of salt and sulfur may be amazingly rapid in destructive action on steel casing.

A recent survey covered failure of oil string casing in 76 comparatively shallow wells in the Permian Basin area. Known costs for the repair of 40 of these totaled over $540,000, or an average of $13,400 per well, not considering production lost before and while repair work was in progress.

Some operators, therefore, are attempting to exclude all well fluids from contact with the outer surface of the all-important oil string. This is accomplished by cementing the intermediate casing string from the shoe to the surface, and by cementing the oil string from the shoe to a point well within the intermediate string. Others, at present, seem satisfied to isolate only those zones most important from the standpoint of production or damage.

The foregoing facts result in widely differing casing and cementing programs in different fields and with different operators in the same fields. The intermediate casing string is cemented by multi-stage procedure in some programs, the oil string in others; in still others both strings receive this procedure. Some operators still get by with single stage cementing.

The first and still most widely used multi-stage procedure consists of displacing through the shoe by conventional plug method as much cement as formations should support; finding top of cement with temperature survey; gun perforating above this point and recementing with either plug or cement retainer method as indicated by conditions.

FAILURE OF conventionally applied cement jobs in the Permian Basin, coupled with costly reconditioning jobs where casing has failed through attack in exposed sections, make the placing and assurance of a good cementing job of prime import. The author describes a method whereby the cementing is carried out as a multi-stage operation, and illustrates the method devised.

Bad Features

This procedure has several objectionable features:

First, it is quite expensive due to lost rig time waiting on cement between stages, cost of perforating, testing, and frequent squeeze jobs required to seal perforations.

Second, it does not promise a completely efficient cement job.

It is common practice to perforate 10 to 50 feet above cement top shown by temperature survey. Thus, a portion of the casing may remain uncemented or incompletely protected by contaminated or channeled cement, especially below the perforations. Gun perforations may not be spaced uniformly or at the same level, probabilities which further detract from chances for good cement jobs. Such perforations result in fluid being jetted straight out against the hole wall and may encourage caving or opening of previously sealed porous formations. Since the point of perforation will not

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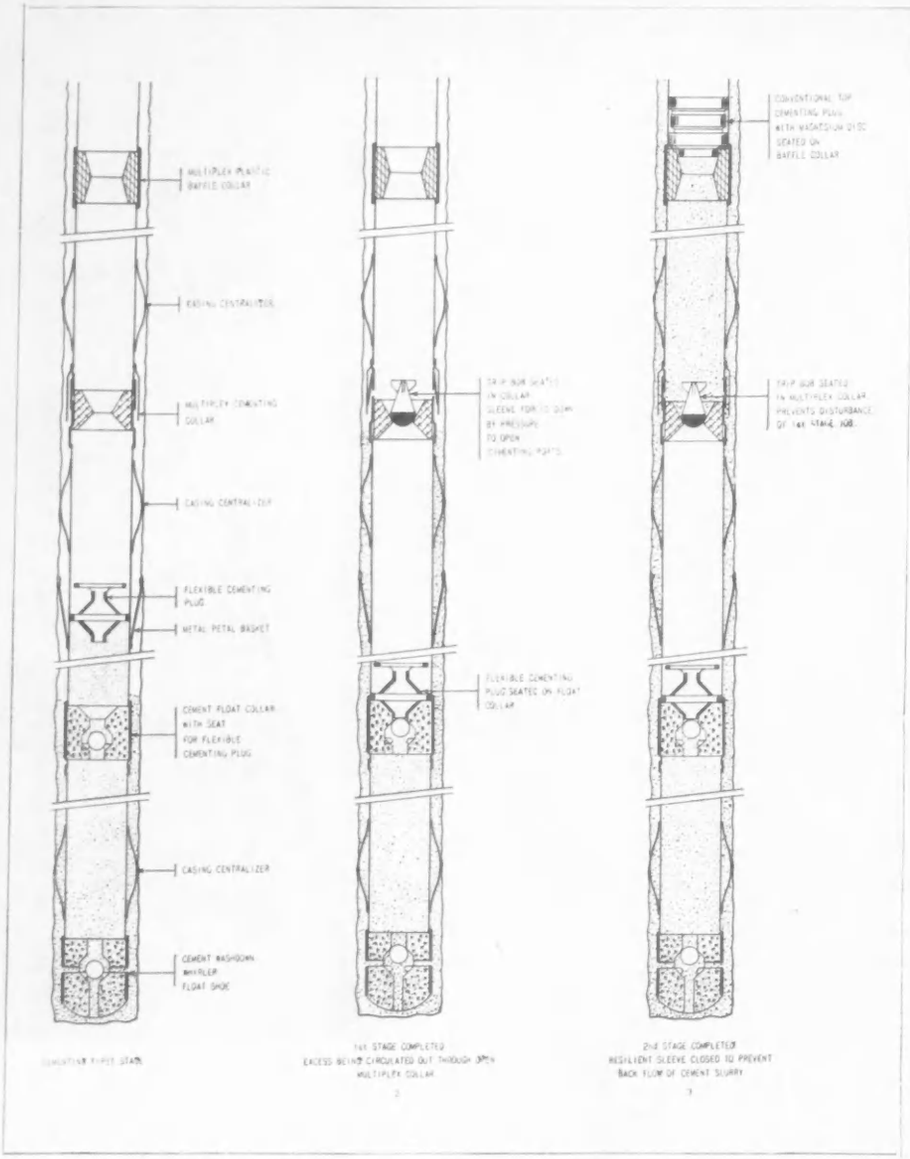
MULTIPLEX PLASTIC BAFFLE COLLAR
CASING CENTRALIZER
MULTIPLEX CEMENTING COLLAR
CASING CENTRALIZER
FLEXIBLE CEMENTING PLUG
METAL PETAL BASKET
CEMENT FLOAT COLLAR WITH SEAT FOR FLEXIBLE CEMENTING PLUG
CASING CENTRALIZER
CEMENT BASHDOWN WHIRLER FLOAT SHOE
CONVENTIONAL TOP CEMENTING PLUG WITH VACATION DISC SEATED ON BAFFLE COLLAR
TRIP BOB SEATED IN MULTIPLEX COLLAR PREVENTS DISTURBANCE OF 1st STAGE JOB
FLEXIBLE CEMENTING PLUG SEATED ON FLOAT COLLAR
1st STAGE COMPLETED
2nd STAGE COMPLETED
RESILIENT SLEEVE CLOSED TO PREVENT BACK FLOW OF CEMENT SLURRY

Schematic diagram of cementing collars and metal petal baskets as used in multiplex cementing to build cement column to desired height in annulus.

be known in advance, precautions for centering the casing at critical points will be difficult. Furthermore, excessive elapsed time between stages may encourage bridging of the hole, preventing reestablishment of circulation completely or in part.

More Efficient Job

Multiplex cementing equipment and procedure offers a favorable possibility, at least, of accomplishing a more efficient cement job at considerable saving in time and expense.

Running and cementing a string of casing with multiplex cementing equipment has been taking from 0 to 12 hours longer than required to run the same amount of casing and cement one stage. However, an average saving of 48 hours, when compared with two-stage gun perforation method has been experienced. Although equipment costs are somewhat higher and mud loss may be greater due to contamination, the over-all saving, particularly of costly rig time, is considerable.

Multiplex cementing equipment and procedure offers the possibility of a more efficient cement job. Location of stages at most favorable points, with relation to formations, and installation of centering equipment at critical points, adjacent to outlets, are possible. Use of excess cement permits circulating out that portion of each initial stage that is normally contaminated or channeled and allows for the building of a continuous block of clean, pure cement over the desired span. Multiplex cementing ports, being uniformly spaced around the circumference of the collar and at the same level, further encourage this result. Down whirler ports permit starting each section of the cement block well below the inner ports of the collar reducing possibility of leakage as well as the jetting action directly against the hole wall. The almost continuous circulation of the well reduces the possibility of bridging or channeling.

Even if an occasional multiplex cementing collar should require recementing, the more favorable possibilities of accomplishing a good cement job even then, recommend continued use by those who have tested this procedure extensively.

Results Favorable

Over 150 multiplex cementing jobs have been attempted in this area during the past 18 months. Results have ranged from complete success to dismal failure. Fortunately, successes have outnumbered failures by about four to one. All job failures have been considered as failures, regardless of cause.

Standard practice has consisted of locating multiplex cementing collars and metal petal baskets in the first dense formation above the zone most susceptible to breakdown and using an excess of cement to insure covering each span completely, thus building a continuous column of cement from the shoe to the desired level.

Experience has demonstrated the efficiency of the metal petal basket, correctly positioned below the multiplex cementing collar, to relieve lower formations of the weight of subsequent stages. It is believed that they should be so mounted as to be able to slide to prevent possible damage when casing is raised from slips, and that they should be located far enough below the multiplex cementing collar to provide a pocket for cement slurry from previous stage which will not be disturbed by circulation through the multiplex whirler ports. This undisturbed pocket of slurry will thus have time to thicken and better seal the basket by the time weight of subsequent stage is imposed. When the basket is positioned directly over the multiplex collar it is washed clean by circulation and must seal on fluid slurry. Also, it is more suspectible to damage in such position.

An excess of cement is recommended to offset some unexpected loss into formation and some contamination due to mixture with mud. This excess is circulated out between stages, leaving, theoretically at least, clean, pure cement below the point washed, on which to start the next stage.

Location Important

Selection of the proper location for multiplex cementing equipment, with relation to well formations, is of utmost importance. Some job failures have been due to incorrect location of equipment in the casing string or an attempt to span too great a distance with a single stage, resulting in the breakdown of some

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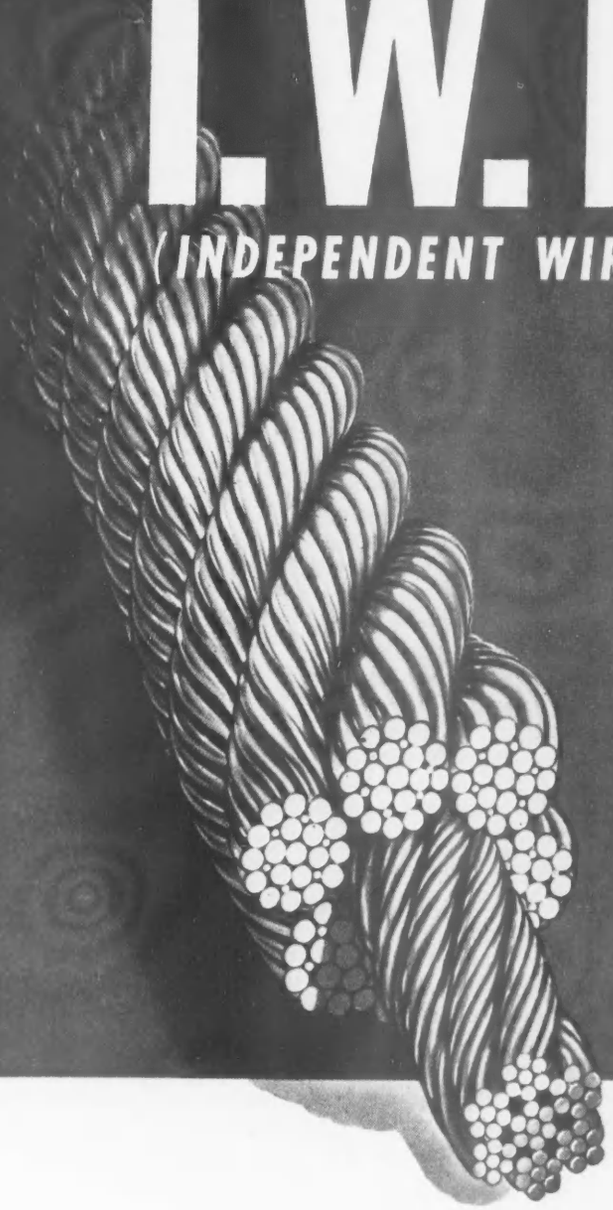

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intermediate formation or contaminated cement at a critical point.

Calculation of cement volume for each stage is also an important factor. Enough must be used to assure complete coverage of the desired span with uncontaminated slurry. Too much excess may make it difficult to break circulation after tripping the next collar, contaminate an excessive amount of expensive mud or scour off a previously sealed zone of lost circulation. Several failures have undoubtedly been due to an insufficient volume of cement, especially on the initial stage; some may have been due to too great an excess.

Caliper surveys, electric logs, drilling time logs and samples, plus previous experience in the same area, are all of value and should be studied carefully in selecting locations for equipment and in calculating cement volumes. Type of cement and weight of slurry also affect results but vary in different areas under different conditions of depth and temperature.

Casing Centralizers

Centering of the casing at critical points is apparently quite important. It has been the practice to install casing centralizers immediately above and below multiplex collars in an effort to insure a uniform annular sheath of cement outside the ports to withstand a pressure test after drilling out. Centralizers are also positioned immediately below each metal petal basket to encourage uniform expansion of petals.

One problem about which little has been done as yet and which probably has considerable effect on consistent results has to do with mud fluid and its intermingling with the cement slurry. A considerable amount of costly mud is contaminated and discarded on each multistage job. Reduction of this loss would reduce the over-all cost of the multiplex procedure. Some job failures probably result from leaving contaminated or channeled cement at critical points. Inquiries have been instigated toward finding or developing a chemical "blanket" which might be effectively used to separate mud from slurry outside the casing and thus reduce contamination and channeling. Experiments in using a column of clear water as a separator have not proved successful. In the meantime, best possible mud conditioning prior to cementing is recommended.

Circulation Time

There is still some difference of opinion as to the length of circulation time advisable between stages. Some operators prefer to circulate three or four hours between stages to permit the initial set of the slurry previously placed and to recondition mud contaminated in circulating excess cement out of the hole. Others circulate only long enough to remove the excess. In theory, at least, the former practice seems best but comparative results indicate that the latter method results in more consistent success.

The possibility of cutting out the ports or back pressure valve sleeve of the multiplex cementing collar by prolonged circulation has been considered and several instances of apparent back pressure valve failure after several hours of circulation, especially on the middle stage of a three-stage job, have been experienced. Laboratory tests indicate, however, that cutting out will not occur even under conditions more severe than found here. As a result of this experience on three-stage jobs it is now the practice to wait about 15 minutes after displacing second stage before releasing pressure, and seldom is any flow-back noted. It seems possible that prolonged circulation may distort the resilient valve sleeve and that a time interval might permit it to creep back to a perfect seal over the inner ports.

Best results have been obtained where plugs were definitely "bumped." There has been little evidence of failure of the flexible cementing plug to shut off positively when pumped to the float collar with seat. On several multiplex cementing jobs, triplex cementing equipment has been used on the bottom of the string due to an open hole below the shoe; on such jobs, a 2⅛-inch bridging ball is placed on top of the flexible cementing plug to assure a shut-off should the flexible plug pass through the triplex flapper valve float collar. Attachment of a rigid magnesium disc to the bottom of a conventional cup type rubber cementing plug has made "bumping" of the final plug on the plastic baffle collar equally efficient. On a three-stage job it is necessary, of course, to measure displacement on the second stage, since there is no way at present to "bump" this plug.

The cause of some failures may be due to the practice of "washing up on top of the plug" and it is recommended that this not be permitted. Occasional instances where no cement or contaminated cement is found below the plug may result from this practice.

It has been common practice to use a quick change type of cementing head on the casing to permit insertion of the trip bob with least possible loss of time. When this head is opened for insertion of cementing plugs behind a large volume of cement slurry, a considerable amount of air rushes in behind the falling column of heavy fluid and ahead of the plug. While this is a controversial subject, results may be adversely affected by this "bubble" of air. It might be advisable, therefore, to use a special plug-container cementing head which would permit insertion of the plug into the fluid column without stopping pumps or permitting air to enter.

Current Applications

At the present time three companies have adopted standard programs of multiplex two-stage jobs on intermediate casing strings in one field. Experiments are under way in other fields and with other operators. These intermediate strings vary from 3600 to 5000 feet in length in different fields.

Four companies, on operations in six different fields, have adopted the multiplex two-stage method as standard procedure on oil strings ranging from 8000 to 10,000 feet. Three-stage procedure is standard with one active operator when casing is set through the Ellenberger. Under certain conditions this same operator penetrates the Ellenberger only partially, then swings casing with a triplex cementing shoe at the gas/oil contact and uses two or three stage multiplex procedure above, depending on well conditions.

It seems probable that both equipment and procedures will be improved as greater experience shows the way. Nevertheless, results to date indicate that multiplex equipment offers considerable advantage over previously used methods of multi-stage cementing in this area, at least.

About the Author

R. D. McBRIAN, a native Kansan, started work immediately after school on a cable tool rig in the shallow fields of that state. He worked briefly in various departments of the oil industry in Kansas, Oklahoma, Arkansas and Texas. He joined Baker Oil Tools, Inc., in 1932 as a salesman in the East Texas field. Transferred to West Texas in 1934, he advanced to the position of district manager of the West Texas-New Mexico district in 1936. He remained in that capacity until 1948, when he was transferred to Houston as assistant division manager of sales and service.

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What a "unit of work" is depends, of course, upon the industry involved. In oil-country rotary drilling, the ton-mile is widely accepted as a basis for computing actual rotary-line costs. In the coal country, "unit of work" could be a ton of coal hauled up a plane; or a ton of earth handled on a dragline job. In many cases, it isn't difficult to record or closely estimate the totals accounted for by a given rope—and thus learn the rope cost per unit of service rendered.

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A New Type of Porosimeter

By EMIL KAYE
and
M. L. FREEMAN, JR.
The Atlantic Refining Company

THIS PAPER presents a new type of porosimeter, its operation, and a brief history of its development. The precision of this new instrument, which uses atmospheric air expanded from a constant volume cell, was found to be 0.6 percent for 96 percent of the measurements. Originally presented before the Spring Meeting, Southwestern District, Division of Production, API, the paper is here reproduced substantially in full.

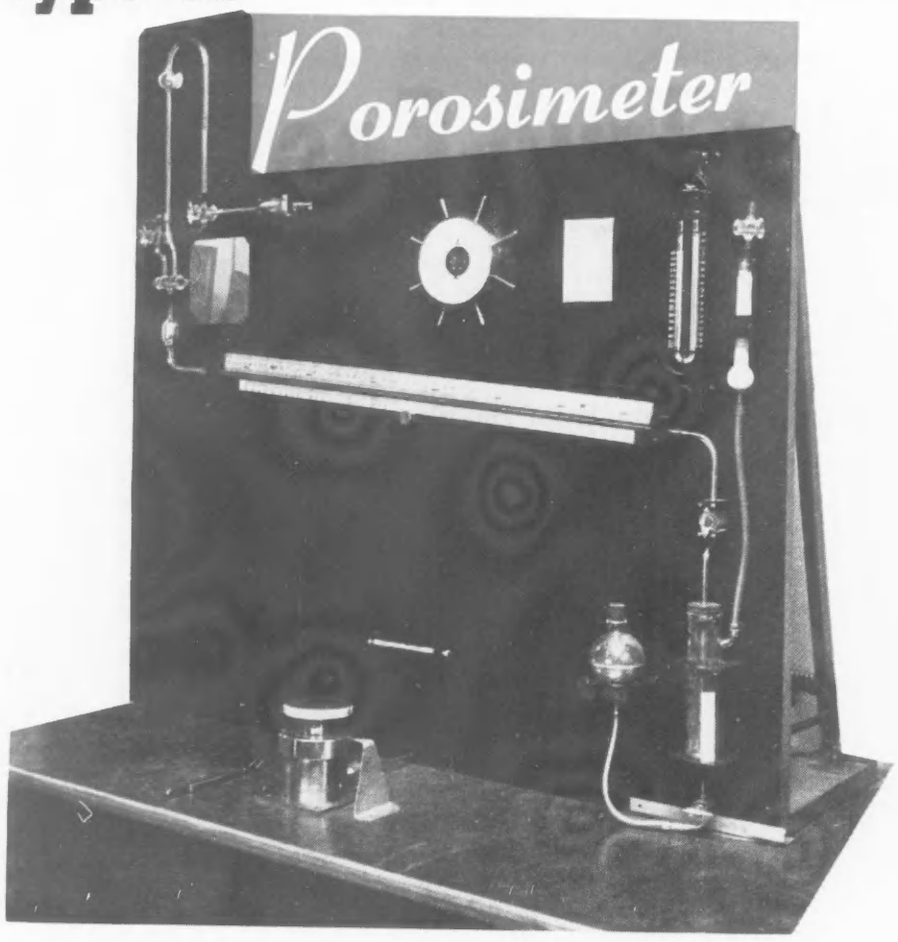

FIGURE 1. The instrument.

PRIOR to development of the new porosimeter, the methods of porosity measurement commonly used were the Washburn-Bunting, the high pressure mercury pycnometer, and the saturation weight method. The first two methods filled the core with mercury and prevented a check of the porosity value and any further use of the core. The porosities obtained with either of the above instruments generally did not check with the value by saturation.

In view of the importance of an accurate porosity value, particularly in the laboratory in restored state and relative permeability work, a review of various methods of porosity determination with regard to a better evaluation of this property of the rock was felt in order. After consideration of the literature, several types of instruments were constructed using air as the measuring medium to avoid sample contamination. Of these instruments the Bureau of Mines' high pressure type of porosimeter[1] gave satisfactory precision, but it had operational drawbacks that did not meet with the writers' idea of ease of operation for laboratory production work. The instrument finally developed uses atmospheric air expanded from a constant volume sample cell into an inclined manometer previously evacuated and filled with mercury. The volume of the air on expansion is a function of the absolute volume of the core in the cell. Bulk volume is then determined

TABLE 1

Typical Porosity Data on Six Cores

Barometer 29.70. Temp. 76°F., Mercury Setting 8.0, Operator: Wm. Grubb, Paper No. 901-24-C Date: 2-18-48.

Reference Volume		Core		Core		Core	
	6.00 cc		ABF		ACE		ACO
Observed Volume	6.02		5.84		6.73		6.23
	6.02		5.85		6.74		6.23
		5.85 cm³		6.74 cm³		6.23 cm³	
	7.00 cc		ABH		ACF		ACP
Observed Volume	6.98		5.68		6.78		6.14
	6.98		5.70		6.78		6.14
		5.71 cm³		6.78 cm³		6.14 cm³	

TABLE 2

Sample of Bulk Volume Measurement Data

Date: Jan. 5, 1948		Operator: James M. Carlisle
Core: 1	Well: X	Field: Y
Depth: 8849'-50'	Saturant: Brine Spg. 1.058	Permeability: 3.6 md

(1) Saturated wt. gm.	16.700
(2) Dry wt. gm.	14.990
(3) 1-2 wt. gm. brine	1.710 ÷ 1.058 = 1.62 cm³
(4) Suspended wt. gm.	8.993
(5) 2-4 wt. gm. brine disp.	5.997 ÷ 1.058 = 5.67 cm³
ϕ ml by H_2O	1.62 cm³
Va by H_2O	5.67 cm³
Vb by H_2O	7.28 cm³
Va by K&F	5.65 cm³
ϕ by K&F	1.64 cm³
ϕ Average	1.63 ÷ 7.29 x 100 = 22.4% ϕ

ϕ H_2O 1.62 x 100 = 98.9% saturated
1.64

ϕ average = 1.63
ϕ = pore space in cm³
Va = absolute volume of core cm
Vb = bulk volume of Core cm³

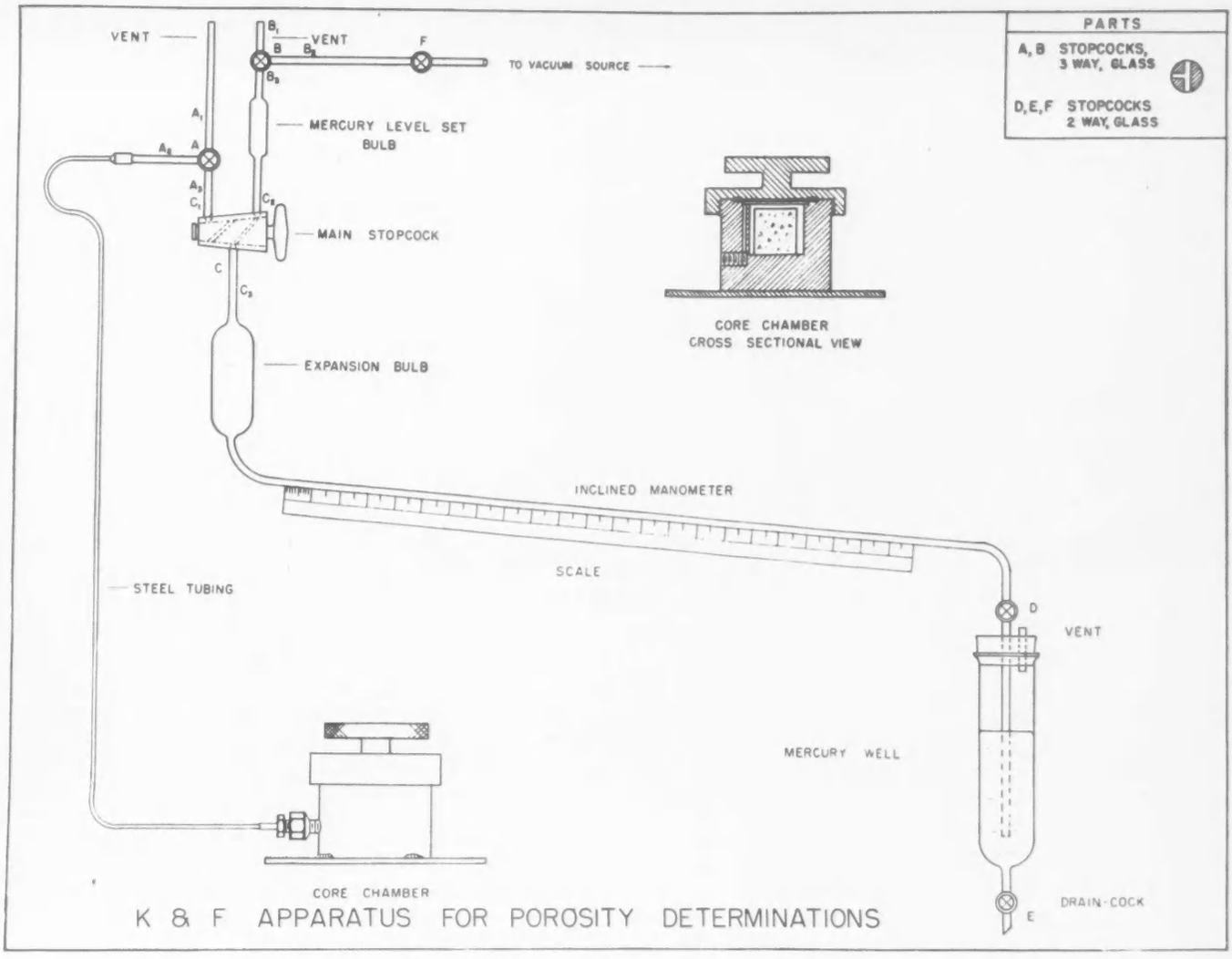

FIGURE 2. Diagram of Kaye-Freeman porosimeter.

by the saturation suspended weight method, and porosity is calculated by differences.

This instrument applies the principle of Boyle's law to the measurement of the absolute volume of the core sample. Boyle's law states: $\text{Volume} = \frac{1}{\text{pressure}}$ (Temperature constant)

or $P_1V_1 = P_2V_2$

where $V = \text{Volume}$

$P = \text{Pressure}$

This principle as used in the described porosimeter expands the air at atmospheric pressure from the sample holder into the variable volume of a manometer. This manometer has been previously evacuated and filled with mercury. The volume of the expanded air changes with variations in the absolute volume of the sample placed in the holder. The expanded variable volume is read from a scale under the manometer graduated in hundredths of a cubic centimeter.

As seen in Figure 1 the manometer is connected at one end with a vented mercury reservoir and at the upper end through a two-way stopcock to either the sample holder or a vacuum pump. The instrument is operated by placing a sample in the holder, pulling a vacuum on the manometer, filling it with mercury up through the two-way stopcock, and then opening the sample chamber to the evacuated manometer.

Laboratory Procedure

The laboratory procedure in running this porosimeter is as follows: A group of plugs 2.1 by 2.3 centimeters are drilled, extracted by pressuring a solvent

TABLE 3

Volume of Solid Material Plus Entrapped Voids in Cores Determined on Different Runs of K & F Instrument

Core Number (R Indicates Round Core)	Volume in CM³ of Solid Material Plus Entrapped Voids in Core					Deviation in cm³ of Each Run from Mean	Permeability to Air in MD	Porosity in Percent By K & F
	Run No. I	II	III	IV	Mean			
57	9.29	9.30	9.25	9.25	9.27	+.02, +.03, −.02, −.02	0	8.9
49R	7.47	7.42	7.40	7.49	7.45	+.02, −.03, −.05, +.04	?	9.3
3	9.52	9.51	9.48	9.52	9.51	+.01, .00, −.03, +.01	91	13.5
56	9.15	9.10	9.10	9.14	9.12	+.03, −.02, −.02, +.02	3	14.2
50R	6.91	7.02	6.93	7.02	6.97	−.06, +.05, −.04, +.05	.7	14.5
2	9.15	9.13	9.12	9.07	9.12	+.03, +.01, .00, −.05	130	16.0
52R	6.50	6.43	6.47	6.48	6.47	+.03, −.04, .00, +.01	3	16.8
8	8.95	8.91	8.90	8.87	8.91	+.04, .00, −.01, −.04	96	17.1
58	8.34	8.31	8.27	8.34	8.32	+.02, −.01, −.05, +.02	...	17.2
60	9.48	9.46	9.47	9.45	9.465	+.01, −.01, .00, −.02	...	17.4
61R	6.01	5.90	5.93	5.99	5.96	+.05, −.06, −.03, +.03	4	17.5
4	9.15	9.12	9.12	9.08	9.12	+.03, .00, .00, −.04	108	17.6
6	8.91	8.87	8.87	8.83	8.87	+.04, .00, .00, −.04	531	17.7
22R	5.63	5.67	5.65	5.59	5.63	.00, +.04, +.02, −.04	83½	20.0
6R	5.07	5.10	5.14	5.03	5.09	−.02, +.01, +.05, −.06	38	20.2
61	9.58	9.58	9.60	9.62	9.60	−.02, −.02, .00, +.02	...	20.8
59	8.36	8.35	8.35	8.35	8.35	+.01, .00, .00, .00	...	26.8

*NOTE—These runs were made at separated intervals under different atmospheric conditions. Calibration curves were plotted for each run.

FIGURE 3. Photograph of core cell and volume blocks.

TABLE 4
Frequency of Deviations

Core No.	DEVIATIONS IN CM³ FROM MEAN OF FOUR OBSERVATIONS														
	−.07	−.06	−.05	−.04	−.03	−.02	−.01	0	+.01	+.02	+.03	+.04	+.05	+.06	+.07
2			X					X	X		X				
3					X			X	X X						
4				X				X X			X				
6				X				X X				X			
8				X			X	X				X			
6R		X				X			X				X		
22R				X				X		X		X			
49R			X		X					X		X			
50R		X		X									X X		
52R				X				X	X		X				
61R		X			X						X		X		
56						X X				X	X				
57						X X				X	X				
58			X				X			X X					
59								X X X	X						
60						X	X	X	X						
61						X X		X		X					
Frequency of Occurrence	0	3	3	6	3	8	3	14	7	7	6	4	4	0	0
Frequency Percent	0	4.4	4.4	8.8	4.4	11.8	4.4	20.6	10.3	10.3	8.8	5.9	5.9	0	0

TABLE 5
Reproducibility of K & F Instrument

Precision Limits of Instrument Values for Volume of Solid Material Plus Entrapped Voids in Core	Percent Random Porosity Determinations which will Fall Within Precision Limits	*Deviations in Porosity for Cores of Different Bulk Volumes		
		Bulk Volume in CM³		
		10.0	5.0	2.0
± .03 cm³	69%	.3%	.6%	1.5%
.06	96	.6	1.2	3.0
.08	99	.8	1.6	4.0
.10	99.9	1.0	2.0	5.0

* These calculations do not take into account errors in B. V. ; Accurate B.V. measurements may vary .02cm³ and will increase or decrease the limits given in column one.

$$\frac{\text{B.V.} - \text{(solid material)}}{\text{B.V.}} \times 100 = \% \text{ porosity}$$

through them at 60 psi, and dried. The dry weight is taken. The porosimeter is adjusted for prevailing atmospheric conditions by raising or lowering the level of the mercury in the mercury well until the reference volume obtained by using a standard volume block lies within certain limits on the millimeter scale. The volume scale (the lower scale) is set on the reference volume. The core is then placed in the holder. The mercury is pulled into the manometer slightly past the two-way stopcock, and the air in the core and core chamber is introduced into the manometer and the volume read. Readings are taken until two successive readings lie within .02 cubic centimeters of one another. An average of the two readings is taken. As a rule not more than three readings per core are necessary. Occasionally during a long run, a check for any drift in the scale is made with a standard volume block. Table 1 shows a typical set of results on six determinations on this instrument.

Although the effect of the many small variables in the mechanics of operation of the porosimeter was found to be negligible, variations caused by temperature and barometric fluctuations must be considered. These caused a decided shift in scale reading for a definite volume in the core chamber. These influences necessitate a new setting of the instrument for each change. The present volume scale was designed to permit adjustment for these variables and allows for the change in level of the mercury as the height of the manometer changes.

Reproducability

The reproducibility of the instrument was determined on a group of core plugs of various rock types and a range of porosities. Four measurements were made on each core plug. The deviations from a mean were found to be random and independent of the degree of porosity; therefore, a statistical analysis of the data was possible. Results of this analysis show the instrument to give reproducible porosity values on 96 percent of the determinations with a precision of ± 0.6 percent, and on 99.9 percent of the determinations a precision of ± 1.0 percent. The foregoing precision depends on a bulk volume precision of ± .03 cubic centimeters on a core of 10 cubic centimters bulk volume. Additional work has tended to confirm these values.

After the absolute volume of the specimen has been determined on the porosity meter, the sample is dried again, evacuated while warm, and saturated with brine. The saturated core is then weighed suspended in brine, wiped off, and weighed in a weighing bottle. The difference between the dry weight and the suspended weight is the weight of

the brine displaced; this divided by the density of the brine gives a value which should check the volume obtained in the porosimeter. In the event that these values check, it has been established that the specimen is 100 percent saturated with brine. Until this method was developed, there was no rapid routine method for determining that the core specimen had been 100 percent saturated with brine; consequently, the real value of the instrument is apparent at this point. This establishment of 100 percent saturation is of particular value in all restored state capillary and relative permeability work since the percent calculations in such work are contingent on knowledge of accurate values.

The difference in the dry and saturated weights is the weight of the brine in the pore space of the sample; this value divided by density of the brine gives the pore space occupied in cubic centimeters. Pore space in cubic centimeters plus absolute volume in cubic centimeters gives bulk volume in cubic centimeters and establishes the following equation:

$$100 - \left(\frac{Va}{Vb} \times 100\right) = \text{percent porosity}$$

Where

Va = volume, absolute in cubic centimeters

Vb = volume, bulk, in cubic centimeters

This method of determining bulk volume has proven satisfactorily precise (± .03 cubic centimeters) and tends to correct for any under saturation by including the entrapped air in the absolute volume measured. A set of porosity and bulk volume measurements are shown in Table 2.

After 1½ years of intensive use of this instrument, it can be reported that it meets the need for a precise, accurate porosimeter that is rapid in operation and leaves the sample uncontaminated for further experimental work. The precision, determined by a statistical analysis of the repetitive data obtained on seventeen diversified core samples with a bulk volume of ten cubic centimeters or over, was found to be ± 0.6 percent for 96 percent of the measurements and ± 1.0 percent for 99.9 percent of the measurements. The accuracy of the instrument, uncertain because of insufficient data, is believed to be within 1 percent of the true value.

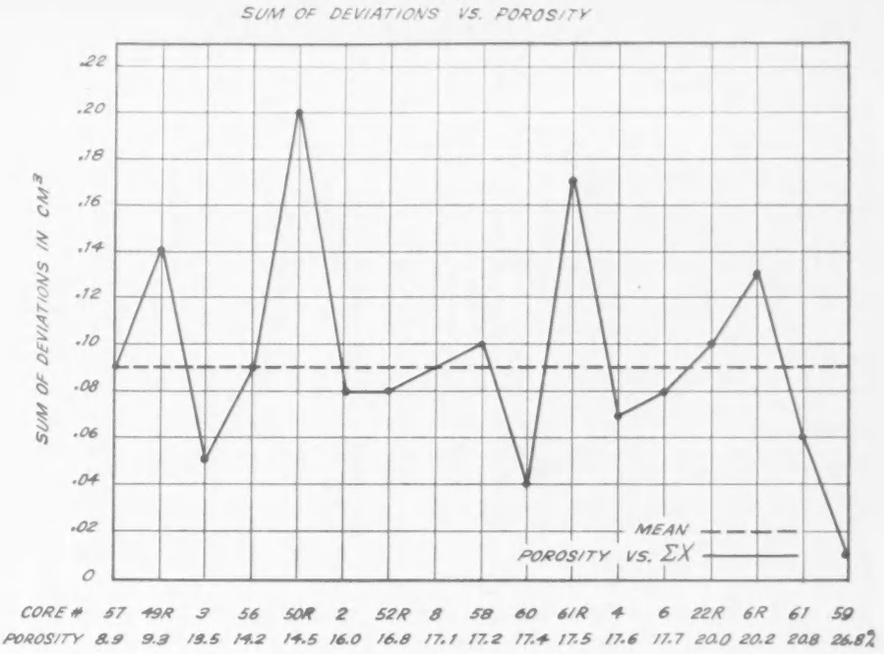

FIGURE 4. Porosity versus sum of deviations.

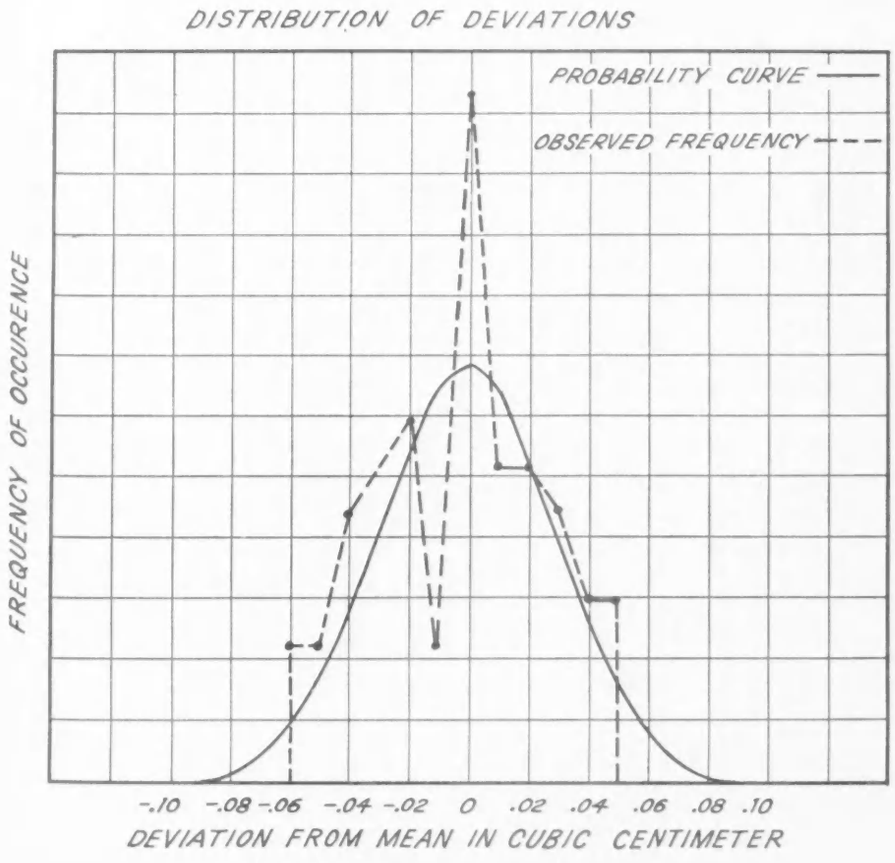
DISTRIBUTION OF DEVIATIONS
PROBABILITY CURVE
OBSERVED FREQUENCY
FREQUENCY OF OCCURENCE
-.10 -.08 -.06 -.04 -.02 0 .02 .04 .06 .08 .10
DEVIATION FROM MEAN IN CUBIC CENTIMETER

FIGURE 5. Frequency curve on 17 cores.

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[1] Tallaferro, D. B., Jr., Johnson, T. W., and Dewees, E. J., "A Method of Determining Porosity," Bureau of Mines Publication, R. I. 3352—Sept., 1937.

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Fancher, G. H., Lewis, J. A., and Barnes, K. B., "Some Physical Characteristics of Oil Sands," The Pennsylvania State College, Mineral Industries, Experiment Station Bulletin No. 12, pp. 65-167, 1933.

TABLE 6

Errors in Bulk Volume Measurement and Their Effect on the Precision of the K & F Instrument

This table is based on the precision of bulk volume measurements by the saturation with Tetrachloroethane or Mercury Pycnometer methods on cores of approximately 10 cc bulk volume.

Deviation in Porosity in Percent Limits	Percent of Determinations which Will Fall within These Limits (Combined Effect of Bulk Volume and Instrument Errors)
± .3%	69%
.6%	94
.8%	97.5
1.2%	98.5

(See table and chart on 98 and 100.)

TABLE 7

A Comparison of Methods of Determining Bulk Volume

(Based on Cubical Cores, B.V. of @ 10 cc: Round Cores B.V. @ 7 cc)

METHOD	Accuracy in CM^3 (Estimated)	Precision in CM^3 on 90% of Determinations	Time Required/ Core in Minutes	EFFECTS ON PHYSICAL PROPERTIES OF CORE			Average Deviation from Saturation or Mercury Pycnometer Method	POSSIBLE ERRORS IN BULK VOLUME IN CUBIC CENTIMETERS			
				Preparation	Effects	Reclamation		Shape		High Permeability	Miscellaneous
								Cylindrical	Cubical		
Saturation W/Tetrachloroethane	± .03	± .02	5	Saturate w/tetrachloroethane	Possible oil extraction	Core must be dried 2 hrs. @ 100° and evacuated 30 minutes.		± .015 Drainage	± .03 Drainage	— .05 Excessive Drainage	(1) Cores with rough or irregular surfaces are more difficult to drain than those with smooth surfaces. (2) This method overcomes error of possible incomplete saturation. (3) Temperature-density errors of saturant, ± .02 cc.
Mercury Pycnometer	± .02	± .01	10	Cores with high permeability saturate with tetrachloroethane to prevent mercury penetration.	Nil—very slight mercury contamination: saturation effects	None—except for saturated cores		+ .01 Trapped Air	+ .02 Trapped Air	— .05 Possible Mercury Penetration + .03 Incomplete Drainage of saturated cores	(1) Care must be taken not to trap an air bubble in the pycnometer + .03 cc. (2) Temperature-density errors of mercury ± .02 cc.
Russell Volumeter Using Tetrachloroethane	± .06	± .06	5	Saturate with tetrachloroethane	Possible Oil extraction	Core must be dried 2 hrs. @ 100° and evacuated 30 minutes.	± .02 cc (Round Cores) of Mercury Pycnometer Value .04 cc (Square Cores)	± .015 Drainage	± .03 Drainage	— .05 Possible excessive drainage	(1) Tedious procedure. (2) Volumeter drainage, and air trapped by glass joint. ± .03 cc.
Russell Volumeter Using Mercury	—.05 to .20 (With correction factor of —.16 cc) .05	± .03	0.5	Cores with high permeability saturate with tetrachloroethane to prevent mercury penetration	Nil—very slight mercury contamination saturation effects	None—except for saturated cores	.16 cc higher than Mercury Pycnometer method. (with correction factor .04 cc)	+ .20 Trapped Air	+ .20 Trapped Air	— .05 Possible Mercury Penetration + .03 cc Incomplete drainage-saturated cores.	(1) Cores trap varying amounts of air up to + .20 cc
Mechanical Measurement	+ .15	± .08	5	Grind surfaces to 90° angles	None	None	.10 cc higher than Mercury Pycnometer Method	.15 Measures Maximum dimensions (high spots)	Method not applicable to square cores	None	(1) This method may be used only on round cores with smooth flat surfaces. Surfaces must be @ 90° angles.
Ruska Instrument	— .30 to + .20	± .03	4	None	Nil—Slight Mercury contamination	None	.09 cc higher than saturation method (tight cores) for cores with high permeability (—.01 to —.26 cc)	+ .04 Trapped Air	+ .20 Trapped Air	— .30 Mercury Penetration	(1) Filling pycnometer with mercury ± .01 cc.
Coating with Collodion: Volume by K & F Instrument	Insufficient experimental work has been conducted to perfect this method Accuracy would depend upon K & F instrument and errors in coating procedure. .10	.08	.....	Coating—dipping and drying	None	Extraction of coating				Method not applicable	(1) This method is not recommended for accurate work in porosity determinations. Combined errors of two K & F readings and errors in coating procedure would reduce accuracy to approximately 2 percent.
Loss of weight in water by paraffin coated core	Insufficient experimental data	Est. .04		Coating	Contamination with paraffin	Extraction of paraffin				Not applicable-paraffin penetration	(1) Imperfect seal-water penetration while weighing suspended in water.
Displacement of water	— .10 to + .30	± .03	5	Saturation with water	Possible leaching or disintegration	Intermittent drying and evacuation 2 hours.	Readings average .20 cc higher than Ruska and Russell Volumeter.	± .03 Drainage	± .05 Drainage	— .05 Excessive Drainage	(1) Errors in reading graduate ± .05 cc. (2) This method gives high values.

March

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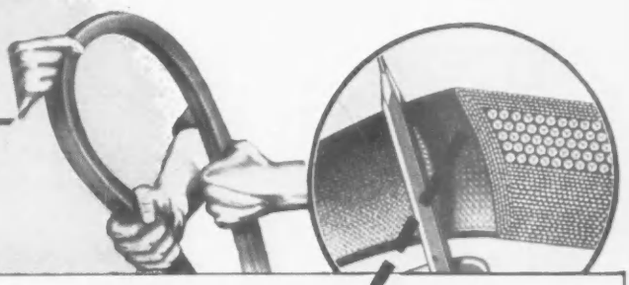

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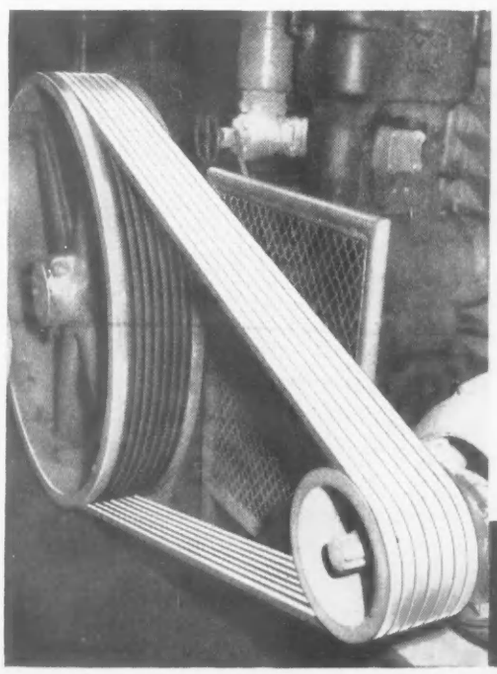

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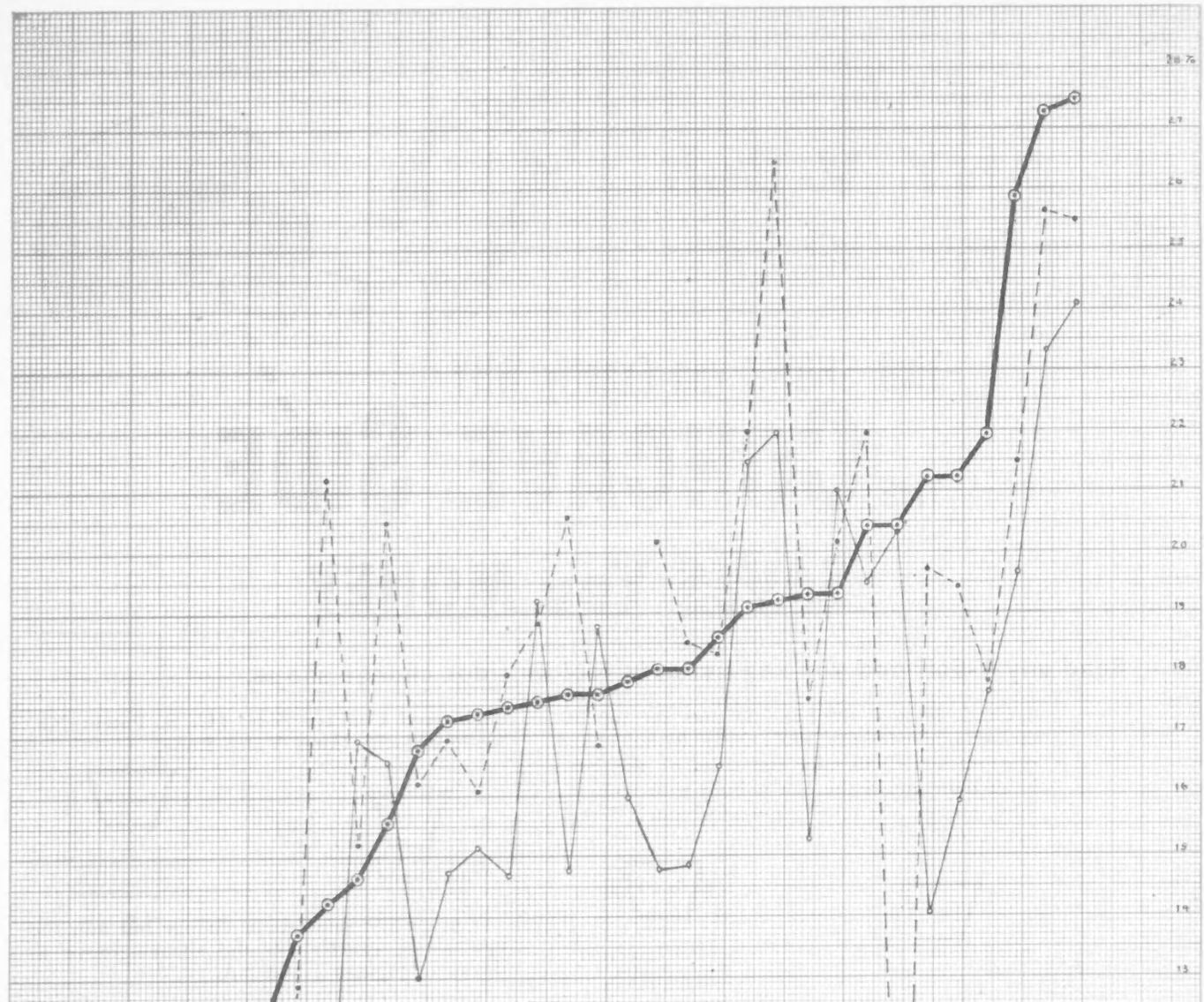


FIGURE 6. Comparative porosities on sandstone by several methods used in the core analysis laboratory.

Drilling Anhydrite with *NaCMC*-Base Mud

By R. W. WADDELL
Consulting Drilling Mud Engineer, Tyler, Texas, and
R. A. WYNNE
Drilling Mud Engineer, Drilling Specialties Company, Bartlesville, Oklahoma

MUD CONTROL for drilling anhydrite is outlined by the authors, who advocate maintaining high pH and combining various additives to secure desired characteristics and weight of fluid. A typical well log illustrates the results obtained when following the program outlined.

IN DRILLING wells in the Arkansas, Louisiana and East Texas area there are encountered sections of anhydrite which vary in thickness and depth. From one to three small stringers of anhydrite are found before reaching the main or massive section, the latter ranging in thickness from 150 to 400 feet and topped at depths from 3500 to 9500 feet. The massive anhydrite lies above several possible producing formations. The Buckner anhydrite, sometimes called the Buckner lime, is found below the Cotton Valley section and immediately above the Smackover lime, one of the good producing zones in this area.

The control of drilling mud through the anhydrite sections has been an extremely perplexing problem. Early operators in this area ignored mud characteristics and drilled these sections with mud watered back from a semi-plastic condition to a pumpable fluid. Naturally, the resultant mud was of very poor quality. From this procedure evolved the technique which was called the "Blue Mud Change Over." The operators divided a reserve pit into three sections: shale, blue mud, and anhydrite mud. In the upper section of the hole the native mud was jetted and retained in the blue mud pit. After the anhydrite was drilled, the pits were cleaned and filled with the reserve mud, and the mud in the hole was displaced. This practice had several possible damaging results: loss of rig time while changing mud; non-protection of the upper hole resulting from using extremely high water loss mud for several days while drilling the anhydrite section; and a likelihood of re-contaminating the complete mud system due to changing the mud gefore all of the anhydrite had been drilled.

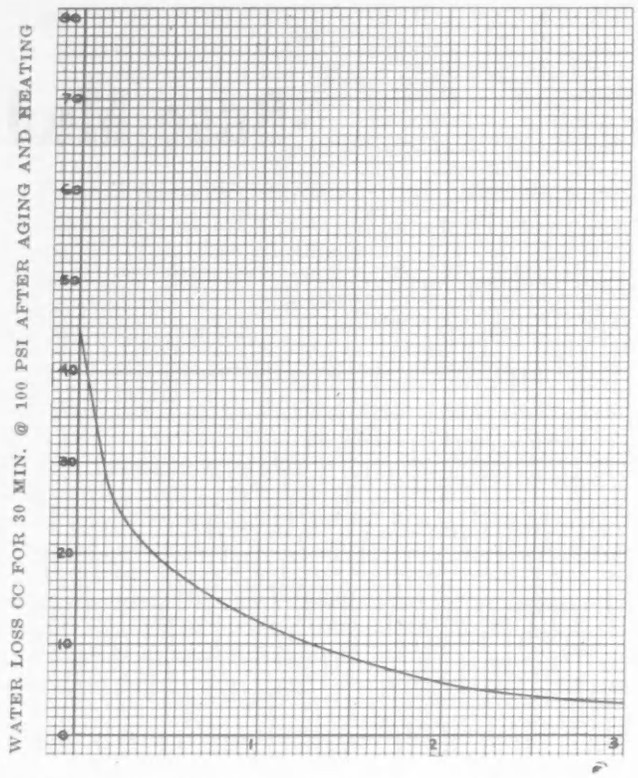
More recently the practice of testing drilling fluid, while drilling anhydrite sections, with one or more of the well-known water softening chemicals such as barium carbonate or complex phosphates in conjunction with caustic soda and quebracho has been followed. These treatments were a great improvement over previous practices and the operators realized how advantageous it was to maintain a good drilling fluid through these sections. Drilling mud engineers, research chemists, and the mud companies have continued in the search for new techniques and materials to apply in combating such drilling problems. Sodium carboxymethylecellulose (NaCMC) is one of the newer mud additives to be put into use, and has proven successful in hundreds of wells in the Ark-La-Tex area for drilling through and beyond the anhydrite sections. This material is a white granular powder, immune to both chemical and bacterial action. It is easy to handle and non-injurious to the skin. The material is readily soluble in hot or cold water and will withstand very high temperatures without charring. It may be added to the mud system through the conventional hopper in the same manner as bentonites or barites. No special precautions or equipment are necessary for its use.

In early experimental applications it was found that by treating the mud with NaCMC alone the cost was excessive and the drilling fluid, though satisfactory in all other respects, had gel properties that were slightly high. Through experimentation it was found that a mud treated with caustic soda and quebracho to a pH of 11.5 to 12, and the addition of a very small amount of NaCMC would retain its properties, at a surprisingly low expense, while drilling the anhydrite section.

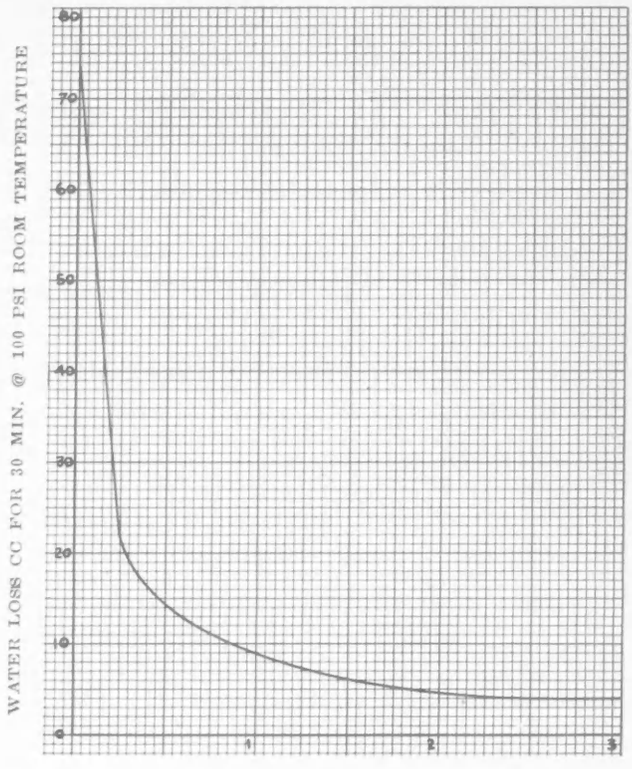
The average drilling fluid in the Ark-La-Tex area is very lightly treated prior to reaching the massive anhydrite. At this point the mud will normally weigh from ten to 11 pounds per gallon, have an API viscosity of 36 to 45 seconds, and a filtration rate of 12 cubic centimeters to probably 50 or 60 cc. In order to prepare properly the mud for anhydrite drilling, the pH, which is usually around 8, should be raised to 11.5 or 12 and the filtration rate lowered to a range of four

Table 1
Typical Well in Beinville Parish, Louisiana

Depth,	MATERIALS USED: Quebracho, Lbs.	Caustic, Lbs.	NaCMC, Lbs.	Weight Lbs./Gal.	API Viscosity	Centipoise Viscosity	Initial Gel	10 Minute Gel	Water Loss, cc.	Cake Thickness In.	pH	$CaCO_3$, ppm
4635	(Mud test before addn. of NaCMC)			10.4	38	10	0	15	19.0	3/32	8	60
4909	825	1210	400	10.4	39	21	0	25	4.3	1/32	12.2	....
5049	150	150	....	10.6	37	20	0	5	5.4	1/32	12	....
5157	150	150	....	10.8	39	25	0	12	5.8	1/32	12	....
5283	200	200	....	10.9	38	21	0	5	6.1	1/32	12	120
5398	250	250	100	10.2	39	15	4	38	14.0	2/32	11.8	300
5508	350	350	300	10.3	40	14	2	40	12.8	2/32	11.7	400
5614	350	350	100	10.4	39	18	0	27	10.0	2/32	11.8	920
5738	100	100	....	....	....	....	....	....	....	....	....	....
5776	100	100	....	....	....	....	....	....	....	....	....	....
5889	0	0	....	10.6	38	16	0	25	10.5	2/32	11.6	840
5897	100	100	....	....	....	....	....	....	....	....	....	....
5999	100	100	....	....	....	....	....	....	....	....	....	....
6073	150	100	....	10.8	40	20	2	38	10.9	2/32	11.5	800
6119	150	75	....	....	....	....	....	....	....	....	....	....
6161	250	125	....	10.9	41	20	0	35	11.5	2/32	11.5	800
6240	300	175	100	....	....	....	....	....	....	....	....	....
6240	250	125	....	10.8	41	22	0	20	10.4	2/32	11.5	800
6278	150	75	....	....	....	....	....	....	....	....	....	....
6336	300	150	100	....	....	....	....	....	....	....	....	....
6417	250	125	....	....	....	....	....	....	....	....	....	....
6495	150	75	....	....	....	....	....	....	....	....	....	....
6578	150	75	....	11	41	19	0	25	10.5	2/32	11.5	800



Native mud heavily contaminated with $CaSO_4$ and treated with NaCMC after aging and heating.



Native mud heavily contaminated with $CaSO_4$ and treated with NaCMC at room temperature.

cc. to seven cc. To obtain mud of this type an average treatment would be; ¾ pound per barrel of quebracho; 1¼ pounds per barrel of caustic soda; and ½ pound per barrel of NaCMC. The resulting fluid will maintain approximately the same viscosity as was found in the original mud, but the gels will be lowered appreciably.

While the massive anhydrite section is being drilled it will be necessary to add caustic soda and quebracho in sufficient quantities to maintain a proper pH of not less than 11 since the most economically controlled fluid should never have a pH below 11 or a "P" alkalinity below 1.0. A small amount of water should be added at all times, and while drilling in the upper section of anhydrite it may become necessary to increase water additions considerably if there is an excessive buildup of light solids. Small additions of NaCMC will be necessary to maintain the desired water loss through the anhydrite. In the event that there is a drop in viscosity after drilling in the anhydrite for some time, small amounts of bentonite or drilling clay may be added. The filter cake will be found to be of excellent texture at all times.

The maintenance of this mud below the anhydrite is a continuation of caustic soda, quebracho, and NaCMC additions, but in much smaller quantities. Caustic soda and quebracho should be added in sufficient amounts to control proper gel qualities regardless of pH, and NaCMC additions regulated as necessary to maintain the desired water loss. Water should still be added as necessary to prevent a buildup of light solids in the mud.

This system of mud control was developed somewhat through a trial and error method. It was noted in some instances that NaCMC not only controlled the water loss but acted as a thinner on some muds which had calcium sulfate contamination. These muds were of fairly low solid content and never exceeded 900 parts per million calcium. Theoretically, a mud of a pH 12 will suppress the ionization of calcium sulfate to about 800 ppm; regardless of the amount of anhydrite drilled this will be the maximum quantity. Regardless of the footage of anhydrite drilled, field tests will show no increase in calcium in the filtrate provided the pH is maintained in a high range.

Due to the small amount of material used and the simplicity of handling, it is easily possible for one roughneck to make all the necessary additions each eight hours to control the mud properties through the anhydrite. This feature releases the remaining crew members for other rig duties.

Water loss control is positive and simple. The addition of 100 pounds of NaCMC before drilling anhydrite will lower the water loss four to eight cc. and has been known to drop it 12 cc; after drilling in the anhydrite, 50 to 100 pounds will decrease the filtrate rate one to three cc. If the mud is watered excessively or too little caustic is added, resulting in a subsequent pH drop, there is no great change in water loss nor is there danger of fermentation.

The desirable features of NaCMC other than for drilling anhydrite: once the drilling crews have followed the specialized treatment through one well and have become familiar with the purpose of each additive, additional wells can be drilled with very little help from a mud engineer; its wall building qualities are excellent due to a very thin, tough cake; cement contamination does not affect the mud other than to have a slight thinning action; salt contamination up to 15,000 ppm does not appreciably affect it; muds have excellent weight carrying qualities; workover jobs and "drilling in" are aided materially due to the greatly reduced formation contamination; finally, NaCMC has proven itself to be an excellent mud additive that will help the oil industry solve many of its drilling mud problems.

Table I lists a portion of the mud properties and materials used on a typical well in Bienville Parish, Louisiana. The filtration rate of this mud was desired between 10 and 12 milliliters, although it would have been easily possible to have maintained a four to six ml water loss with a slight increase in NaCMC additions. In this well the top of the anhydrite section was encountered at approximately 5100 feet and the base at 5800 feet. NaCMC was introduced at 4900 feet as is noted in the table.

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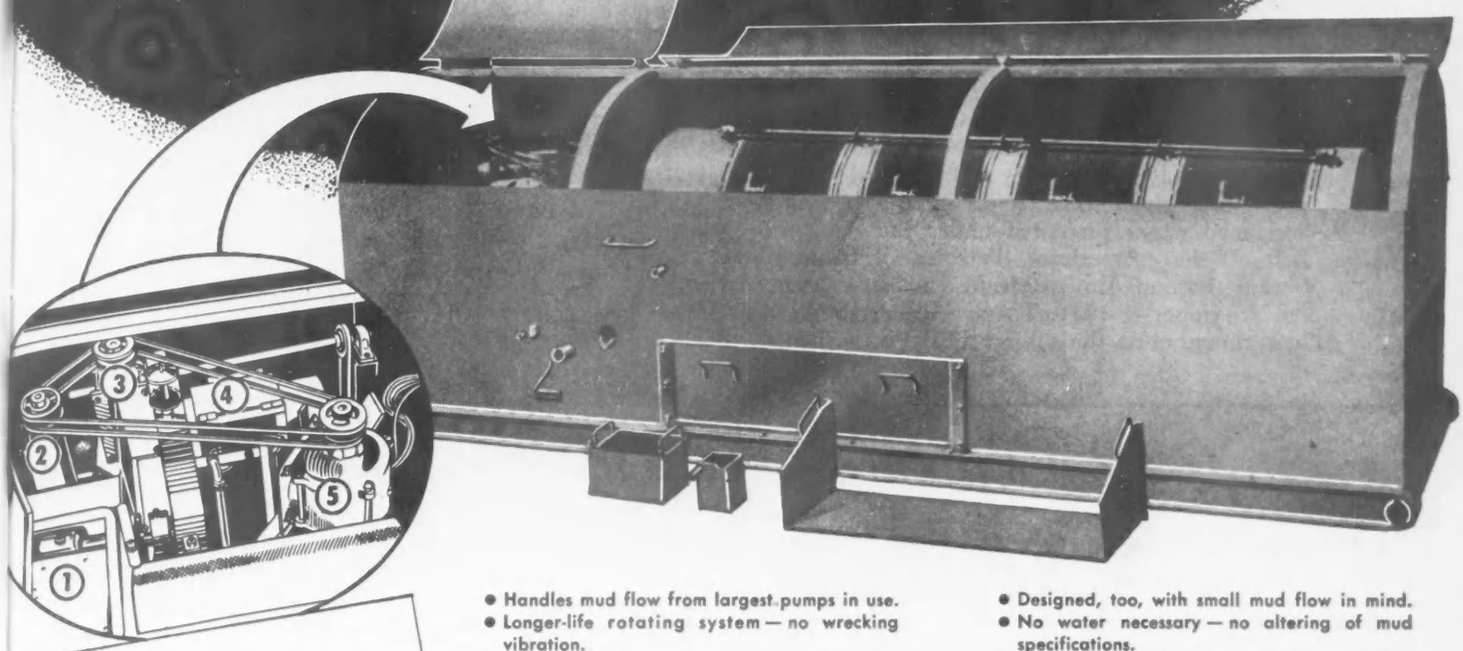

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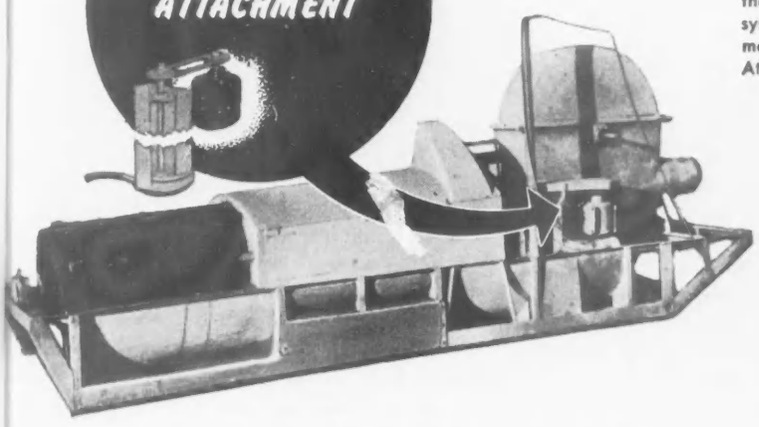

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Causes and Prevention of Drill Pipe and Tool Joint Troubles

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THIS IS THE SIXTH and final installment of a series of articles which describes causes of drill pipe and tool joint troubles and practical ways of preventing them. The series revises a widely acclaimed paper presented under the same title before the American Petroleum Institute's Twenty-Second Annual Meeting at San Francisco on November 6, 1941. To give readers both the new thoughts on the subject and also the benefit of the very thorough discussion presented in the original manuscript, the old text is reprinted in full in our standard type face and the revisions indented in larger type. The effective revision date is August, 1948.

Reprints of the series in pamphlet form will be available shortly. Those desiring reprints should make known their wishes at once.

Part 6 (Conclusion) TOOL JOINTS—Continued

4. Wear on the Outer Surface of Tool Joints

Wear on the outer surface of tool joints has been present since the first joints were used. During the earlier days of rotary drilling, however, the tool joints and the drill pipe generally became worn out at about the same time and, therefore, no particular problem as regards salvage of one or the other was involved.

It is believed that this was due, in part at least, to drilling practices in effect at that time. Most of the pipe was run in compression, which caused it to "spiral" in the hole and thus contact the wall with considerable force. This naturally would result in greater wear on the outer surface of the pipe than occurs with present drilling conditions under which most of the pipe is operated in tension.

Inasmuch as the wall thickness of drill pipe is small as compared with that of tool joint sections, a given amount of radial wear will result in weakening the drill pipe by a greater percentage than it will the tool joint. Thus it can be seen that, in the event appreciable wear occurs on the drill pipe, the life of the drill pipe is likely to be reduced to the point where the tool joint and the drill pipe wear out at about the same time, as was the case in the earlier days.

On the other hand, it seems reasonable to assume that, if the pipe is operated in tension, its contact with the wall of the hole during drilling not only will be lessened considerably, but the contact pressure also will be lower. Both of these factors would be expected to reduce the wear on the outer surface of the pipe and, therefor, other conditions being equal, should result in increased service life. Also, it should be remembered that the most commonly used tool joints have a considerably larger outside diameter than that of the drill pipe—which results in a reduction of hole clearance at the tool joints. Therefore, it would be expected that transverse vibrations in the drill stem might result in greater contact between the wall of the hole and the tool joints than would occur between the wall of the hole and the drill pipe. This naturally would increase the wear on the tool joints and decrease it on the drill pipe.

In this connection, two other changes made during recent years probably also have been responsible for much of the increased wear on tool joints, viz.: the reduction in size of the hole drilled, and the introduction of the internal-flush type of tool joint.

As both of these changes are in the direction of reducing the clearance between the wall of the hole and the tool joint, it is unfortunate indeed that they should have occurred at the same time. The internal-flush tool joint, as the name implies, was designed to eliminate the restriction in bore of the drill stem at the tool joints. In order to maintain reasonable strength of the joint it was necessary to increase the outside diameter, with resulting sacrifice in hole clearance as well as increased projection of the tool joint over the pipe—both of which generally increase the rate of wear on the tools joints.

The internal-flush type of joints was intended primarily for use where the softer formations were to be drilled, thus requiring large volumes of flushing fluid for efficient operation, and where wear on the outer surface of tool joints is not generally a serious problem. However, their use has been extended to some of the more abrasive territories where mud volume is not so important to rate of penetration, but where tool joint wear is much more severe. Under these conditions, the use of this type of joint has not proved economical, and there is at this time a definite trend toward the use of smaller-bore joints even in some of the less abrasive territories.

In the past few years the use

of internal flush tool joints has diminished, in some localities, because excessive O.D. wear makes them uneconomical, but largely because they have no fundamental advantage. There can be no hydraulic advantage in having the tool joints with as large a diameter as the hole size permits and yet have the drill pipe itself relatively small, as is the case with internal flush. It is far better, from a hydraulics standpoint, to increase the drill pipe diameter nearer to the diameter of the tool joint, as is the case with a new line of tool joints known variously as "semi-internal flush" or "extra hole."

It has been observed that the hardness and abrasiveness of the formation being drilled not only affect the rate of wear on the tool joints, but also materially affect the shape or contour of the worn surface. The softer formations usually produce "barrel-shaped" wear on tool joints, an extreme example of which is shown in Figure 46. Tool joints used in drilling the harder formations usually wear more nearly cylindrical, and in numerous instances it has been observed that the lower end of the tool joints becomes battered to such an extent as to result in a rather heavy peening or upsetting at the elevator shoulder, as shown in Figure 47. It is believed that this battering and upsetting is caused by the tool joints hitting against the wall of the hole as a result of transverse vibrations or whip in the drill stem (see Figure 11 in drill pipe section of this paper).

It is difficult to explain the difference in shape of wear on tool joints in hard and soft formations. Some are of the opinion that "barrel-shaped" wear is due to erosion produced by the flow of mud and cuttings past the tool joints, and is more pronounced in the softer formations because of increased velocity resulting from higher rates of circulation. Others think that wear from this action is negligible, and are of the opinion that the tool joints tend to "ream" the hole to some extent, and in doing so they become partly imbedded in the wall of the hole. The softer formations being more easily "reamed" than the harder formations allow the joints to become more deeply imbedded in the wall of the hole—thus resulting in greater concentration of wear at the ends of the joint, particularly the lower or the advancing end.

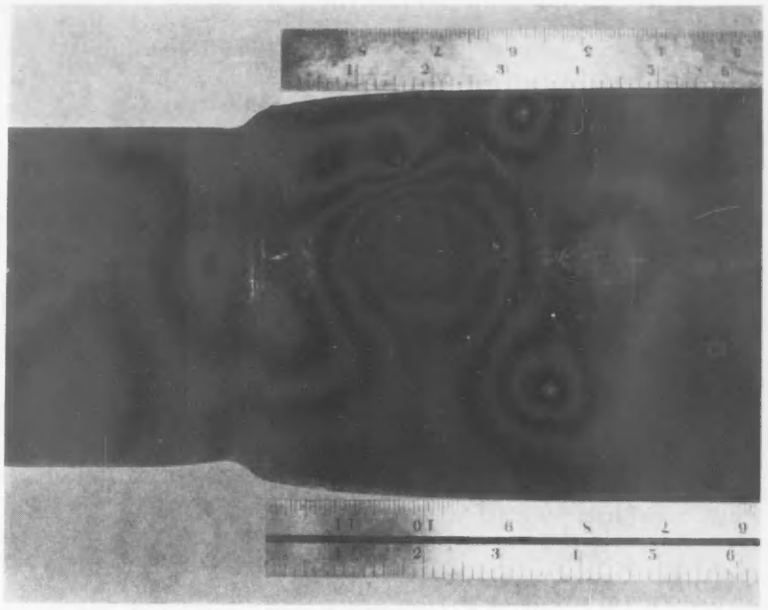

FIGURE 46
Extreme "barrel-shaped" wear on pipe end of a tool joint box used in soft formation drilling.

"Barrel-shaped" wear would be expected to result also from rotation of tool joints in a "key seat" or during the formation of a key seat in the hole. As "key seats" are believed to be more prevalent in soft-formation territories, this may be a plausible explanation.

Quite frequently tool joints become worn eccentrically or wear excessively on one side of the joint. An example of this type of wear is shown in Figure 48. In the majority of cases wear of this type can be traced to the use of crooked pipe which causes a "crank" action in the hole, thus constantly presenting the same side of the joint to the wall of the hole and resulting in concentrated wear on that side.

However, in a few cases, eccentric

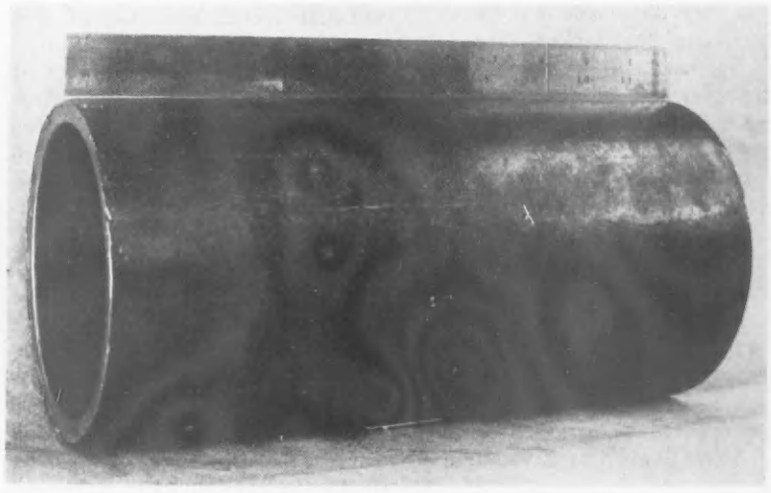

FIGURE 47
"Cylindrical" type of wear on tool joint box used in extremely hard and abrasive drilling. Note peened or upset condition of elevator shoulder at left.

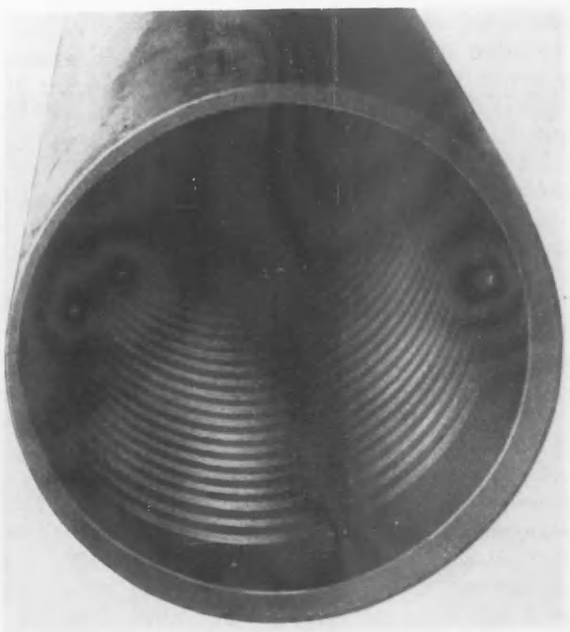

FIGURE 48
Eccentric wear on outer surface of tool joint box.

wear has been experienced when the pipe was found to be quite straight.

As stated in the drill pipe section of this paper, it is believed that this may be due to certain combinations of rotational speed and centrifugal "throw" which result in the same side of the tool joints (and pipe) rubbing continuously against the wall of the hole. Possibly the whole string is rotating, not as a straight line, but as a long spiral, in which one side (the inside of the spiral) is not touching the hole at all. The rather unexplainable part of this theory is why repeated trips in and out of the hole do not so change the "throw" as to present different sides of the tool joints to wear—and thus produce approximately concentric wear. However, the actual facts support the general theory.

In the majority of cases the best assurance of preventing eccentric wear on tool joints is to avoid the operation of crooked pipe.

The necessity for making replacements of tool joints on drill pipe due to wear on the outer surface of the joints has proved very costly to the operators, and much work has been done to reduce this cost. The most practical methods which have been developed up to this time are:

A. The Use of Oversize Tool Joints

In some of the less abrasive territories where the average drill pipe life is only slightly longer than that of the tool joints, a relatively small increase in the outside diameter will increase the life of the tool joints to equal that of the drill pipe, and thus eliminate the necessity of making replacements. When this can be done, it is obviously the most economical solution to the problem. In the more abrasive territories, however, where it is not uncommon to require two to three sets of tool joints per string of pipe, this method alone does not solve the problem completely. Also the benefits to be derived by this method are limited by the amount of increase in diameter which is practical and at the same time maintain sufficient hole clearance for satisfactory operation and to permit the use of fishing tools, washover pipe, etc.

B. Development of Shrunk-on Tool Joints

In recent years much work has been done to improve threaded connections between tool joints and drill pipe for the purpose of eliminating failures in the pipe at the last-engaged thread as well as for the purpose of simplifying the procedure connected with the installation of the tool joints on the pipe. As a result, tool joints which can be shrunk onto the pipe have been developed, thus eliminating the necessity of bucking-on equipment for this work. As this method has simplified the equipment required for making original tool joint installations, it is also possible to make replacements of worn joints at the rig with comparatively little expense to the operator. This type of tool joint, therefore, has met with considerable success in reducing the expense resulting from wear on the outer surface of tool joints.

C. The Use of Wear Subs Between the Tool Joints

Various types of wear subs have been tried, viz: double-pin, double-box, or pin-and-box types. Of these, the double-box sub has a definite advantage over the others in that, for a given length of wearing surface, the overall length of of the sub is a minimum and, therefore, the cost is a minimum. The cost of the tool joints is the same regardless of the type of sub used; therefore, the overall cost is a minimum when double-pin tool joints are used with double-box wear subs.

Wear subs are usually made oversize on the outside diameter in order to provide additional protection to the tool joints as well as to increase the life of the subs themselves. Here again, as in the case of the use of oversize tool joints, the benefits to be derived are limited by the maximum diameter which it is practical to use. The principal advantage to this method lies in the extreme ease of making replacements. No special equipment is required, and replacements can be made on the rig, while pipe is being run, as worn joints appear in the string.

When new wear subs are installed in a string of used drill stem, the diameter of the subs, of course, will be larger than the tool joint diameter; therefore, it is very important that the tool joint shoulders be checked carefully for the presence of fins, bruises, galls, or any other defect which may prevent a uniform bearing between the shoulders and thus result in leaky connections or wabble failures.

Various methods have been devised for rebuilding the outer surface of wear subs when they become worn. The most commonly used of these methods are building up the outer surface with an arc weld deposit, and by the application of strips or sleeves, shrunk on or shrunk on and welded. Although these methods have resulted in increased life of the subs, they have proved to be rather expensive, and in some cases considerable difficulty has been encountered due to warpage and distortion of the threads resulting from the welding heat. Also, in cases of eccentric wear, some difficulty has resulted from the sleeves or strips wearing through on one side and splitting or tearing off. Due to the lower cost of double-box wear subs, however, it is more economical, when they become worn to replace them with new subs, than it is to attempt to rebuild the outer surface. These rebuilding methods have been tried also on the tool joints themselves with about the same results.

Because of the advantages listed, wear subs were used extensively for a time, but have almost disappeared at present because of operational difficulties. The mere fact that wear subs had been added doubled the number of pin and box connections in a string and increased the probability of trouble. Actually the troubles from wabbles and leakage were far more than doubled because in practice only one of the two connections was regularly broken out. The others developed serious troubles because of lack of attention.

Another difficulty was encountered when new wear subs were introduced into a string to replace worn ones. Often the worn tool joints would have "fins" formed on the shoulder faces which interfered with the full diameter shoulder faces of the new subs to such an extent that proper engagement could not be obtained. Such "fins" were the result of mating pins with boxes of different diameters and running them in hard formation. Peening against the wall of the hole upset the larger shoulder out over the smaller joint. Because of this tendency it was found undesirable to mate tool joints or subs having appreciably different diameters. This happened when new wear subs were introduced into a string of worn tool joints.

D. The Use of Hard-Surfaced Tool Joints

The ultimate aim of hard-facing the outer surface of tool joints is to increase the resistance of the joints to wear to the point where they will last the full life of the drill pipe and thus eliminate the expense of making replacements. Although this procedure has resulted in definitely increased life of tool joints, the ultimate aim by no means has been accomplished fully, par-

FIGURE 49
Typical set-up for hard facing tool joints in the field by oxy-acetylene method.

ticularly in extremely abrasive territories.

The results of tests made up to this time indicate that tungsten carbide is the most suitable material for this purpose. Even with this extremely hard material, present indications are that it must be applied in fairly large quantity in order to result in an appreciable increase in tool joint life. Inasmuch as tungsten carbide at this time is a rather costly material, and as present methods of application are slow and expensive, there is some doubt as to the overall economy of this procedure, but the possibilities by no means have been exhausted. Tungsten is now a critical or strategic material, however, and soon may be unavailable for this use.

Some interest now is being shown in the use of hard-surfaced wear subs which seems to offer some promise of success, and field tests also are under way on wear subs having the outer surface flame-hardened. Unfortunately, however, no conclusive results are as yet available on these tests.

The hard surfacing of tool joints has now been developed and proved as a very practical and economical means of combating abrasive wear. It is being used very extensively on new tool joints and on worn tool joints in the field. The effectiveness of the hard surfacing applications depends directly upon the quantity and quality of hard facing material used. In early experiments, relatively small quantities of material were used and results were uncertain, but with the heavy deposits now being used the life of tool joints may be increased 100 percent or more.

Tungsten carbide, applied by the oxy-acetylene gas welding method has proved to be the most suitable material for resisting wear on tool joints. Tungsten carbide has a hardness value of 9.3 on Moh's scale, which, according to relative values determined by the Bureau of Standards, would indicate that it is approximately four times as hard as the quartz crystals which cause most of the abrasive wear on tool joints. Other commercially available materials are relatively ineffective because they are not as hard as these quartz crystals. The gas welding method of application is preferable to the electric method because the high temperature produced in the electric arc causes a greater amount of alloying of the tungsten carbide particles with the steel matrix, and thereby greatly reduces abrasion resistance.

Application of hard surfacing to worn tool joints in the field, has become a common practice. The life of tool joints can be extended indefinitely when correct procedures are followed. Caution should be exercised, however, as only certain types of tool joints can be hard surfaced after installation on drill pipe, with any degree of safety. Tool joints which have been shrunk on or bucked onto drill pipe should not be hard surfaced by welding. Such tool joints depend on hoop stresses to keep them tight, and the heat required

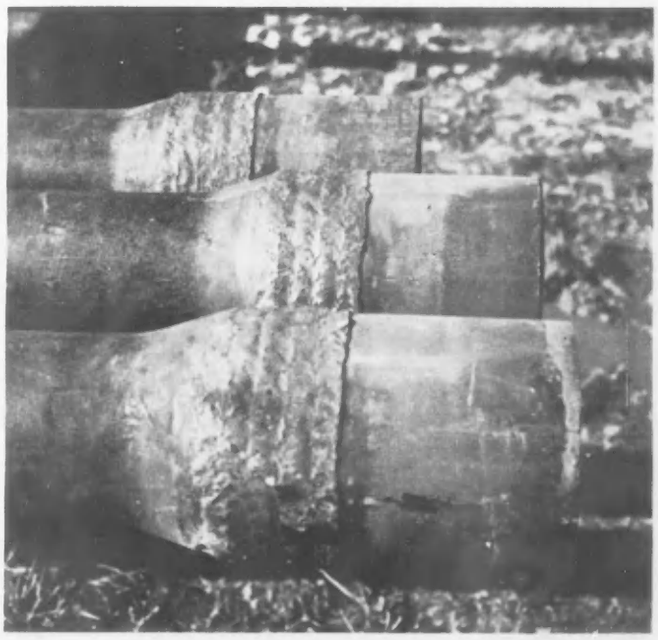

FIGURE 50
Tool joints hard faced in the field with tungsten carbide applied by the oxy-acetylene method.

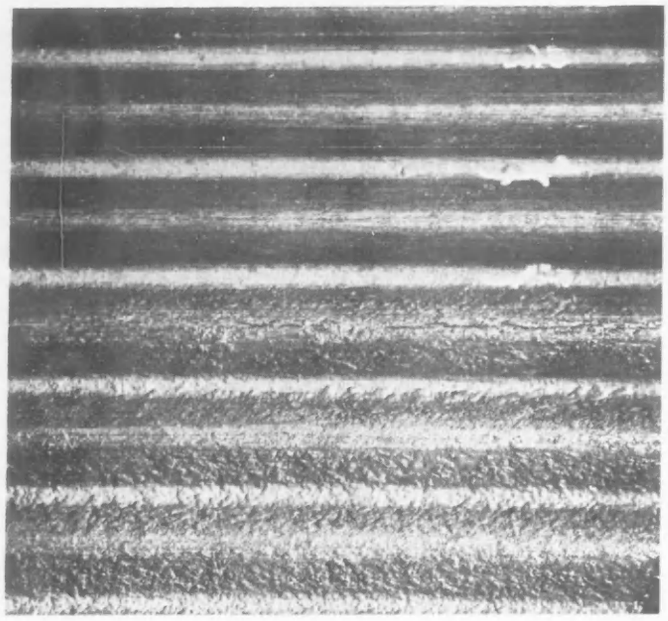

FIGURE 51
Corrosion fatigue cracks in roots of female pipe end threads of 6⅝-inch API tool joint. Note that cracks are limited to corroded areas.

for hard surfacing usually relieves these stresses and failures result. A typical field hard surfacing job is illustrated in Figures 49 and 50.

E. The Use of Long Strings of Drill Collars

The recently increased use of longer strings of drill collars to permit heavier weights on bits, and to keep drill stem in tension, has resulted in reduced abrasive wear on tool joints. Apparently, tool joints do not contact the walls of the hole with as much force, as occurs when the drill stem is run in compression, and wear is reduced. Eccentric wear is almost eliminated.

5. Corrosion-Fatigue Failures in Tool Joints

Because of the great amount of attention being devoted to corrosion fatigue failures in drill pipe, it is of interest that one case of such failures has been observed in tool joints. The mechanics of corrosion fatigue have been discussed comprehensively in the drill pipe section of this paper under 6-c. The tool joint failures occurred in a comparatively new string of 6⅝-inch API Regular tool joints, the fractures starting in the thread roots of the female pipe ends. These threads extend beyond the end of the drill pipe and are exposed to fluid action inside the drill stem.

In this instance seven failures occurred in rapid succession. Examination of the tool joints which failed, and others which did not fail, disclosed corrosion fatigue cracks at the roots of the exposed threads. These cracks are shown in Figures 51 and 52. Note that cracks are evident only in those threads pitted by corrosion.

Corrosion fatigue failures at such points may be attributed to the high bending loads which occur in tool joints attached to 6⅝-inch drill pipe. In a threaded member the stresses tend to localize at the thread roots, with the highest concentration of stresses at the surface. When this highly stressed surface is subjected to corrosion, the formation of cracks is highly accelerated, as explained in the drill pipe section of this paper.

CONCLUSIONS—TOOL JOINTS

Inasmuch as the average contractor or operator is interested much more in the prevention of trouble than in its causes, the authors have summarized herewith the best known practices, gleaned from all available sources, observed wherever wells are drilled by the rotary method. The preventive measures are listed more or less in the order of their importance; but, of course, what is quite important in one area may be of must less importance in another.

To Minimize Tool Joint Troubles

1. Tong the tool joints tightly when going into the hole. A good practice is to use one wrap of the jerk line on the cathead for each inch of nominal pipe size: thus 3 wraps for 3½-inch pipe, 4 wraps for 4½-inch pipe, etc. This is one of the most important factors in the prevention of wabble failures.

When breaking out, check the joints for tightness by observing the force required. If they break apart easily, they should be bucked up tighter the next time they are made up.

2. Avoid damage to pin and box shoulders while the pipe is being hauled; also avoid damage from striking the box shoulders with the end of the pins when stabbing or when jumping the pins out of the boxes with the spring hook. The condition of the tool joint shoulders is very critical, especially in the prevention of wabble failures and leaky joints.

Watch for "dry" or "muddy" pins, and with a ring gage check pin and box shoulders carefully for flatness. Whenever possible, remove high spots

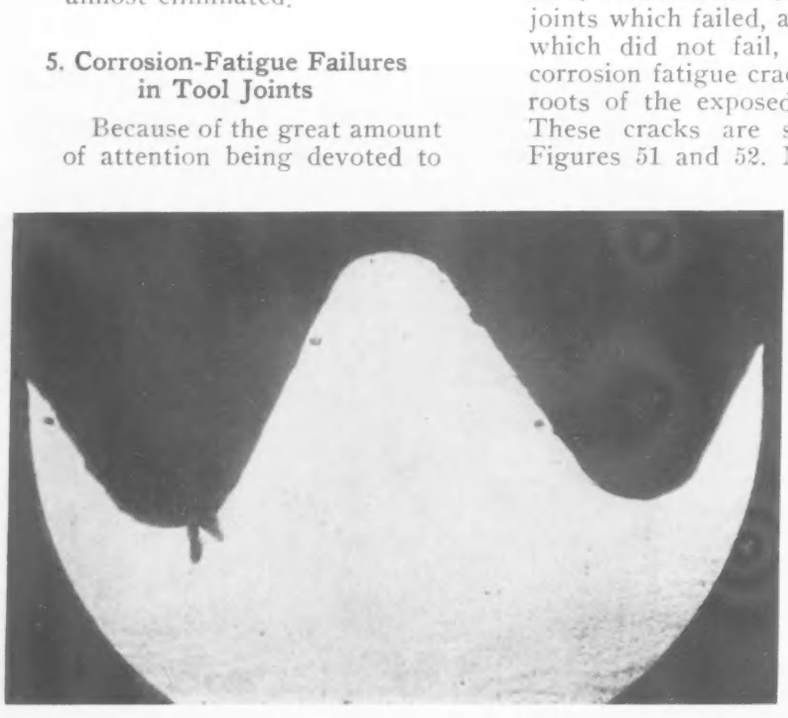

FIGURE 52
Cross section through cracks in thread roots in Figure 51.

*Drilling depth ratings are with 4½-inch drill pipe at 100 r. p. m. Ratings with 3½-inch pipe or at higher speeds given on application.

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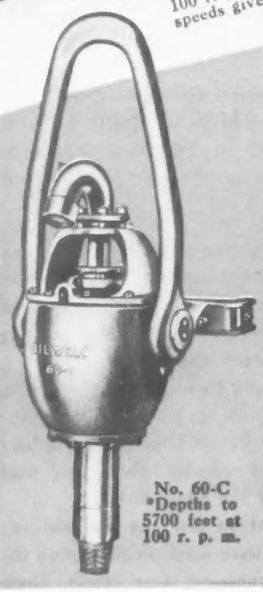
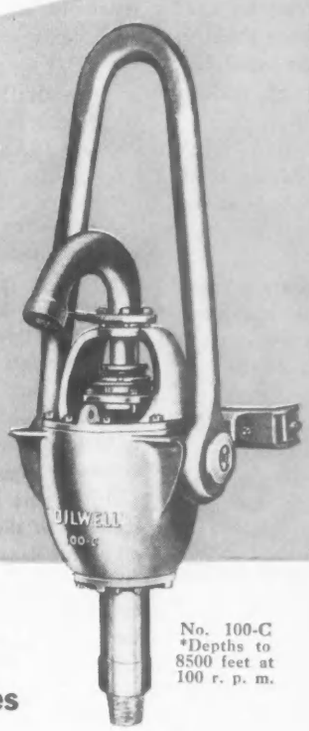


No. 60-C
*Depths to 5700 feet at 100 r. p. m.



No. 100-C
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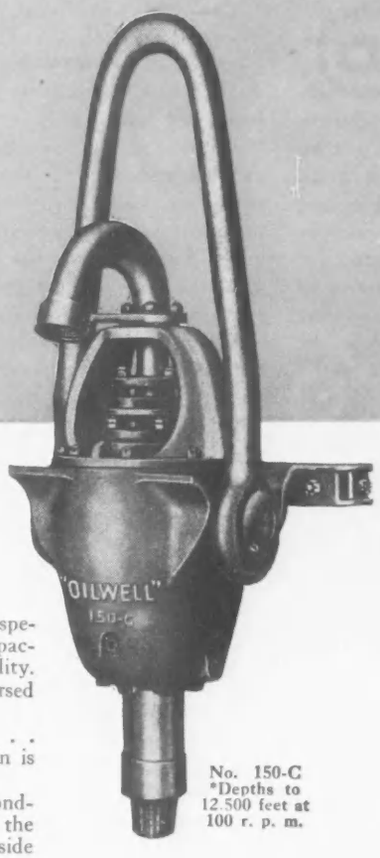
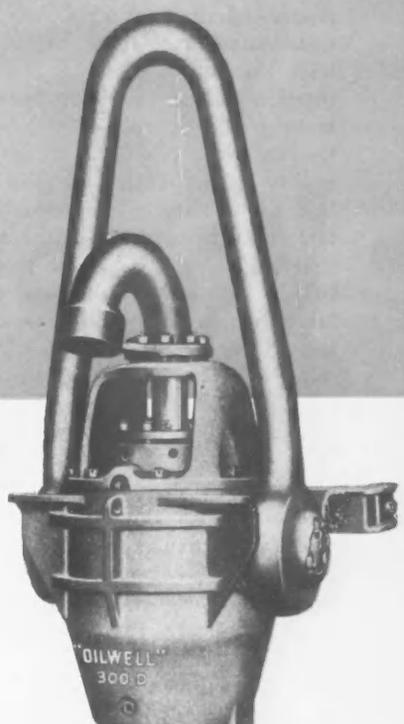


No. 150-C
*Depths to 12,500 feet at 100 r. p. m.



No. 300-D
*Depths to 17,000 feet at 100 r. p. m.

Keep in mind these 10 important features

1. **Heavy-Duty Roller Bearings**—Main bearing is full-apex type, especially designed for its use and proved by outstanding service. Wide spacing of the two bearings carrying radial load assures maximum stability.
2. **Circulating Oilbath Lubrication**—All bearings are constantly immersed in a continuously circulating bath of lubricating oil.
3. **Heat-Treated Forged-Steel Body with Integral Tool-Joint Pin . . .** has large-diameter fluid passage. A left-hand A. P. I. tool-joint pin is cut directly on the body, with ample stock for rethreading.
4. **DI-HARD Wash Pipe**—Abrasion-resisting lining of DI-HARD, bonded to the inside, protects the wash pipe from the cutting action of the fluid. A ground-and-polished armor of DI-HARD bonded to the outside greatly extends the wear-life of both wash pipe and packing.
5. **Self-Sealing Wash Pipe Packing**... requires no adjustments. A convenient fitting facilitates lubrication with waterproof grease.
6. **Streamlined One-Piece Cast-Steel Housing . . .** provides rigid support for all working parts and prevents distortion under heavy loads.
7. **Shock-Absorbing and Wear-Preventing Link-Rest Pads . . .** protect the swivel and the links from destructive hammering of metal against metal.
8. **Large Diameter Heat-Treated Forged-Steel Bail . . .** of one-piece construction has increased thickness at the top to compensate for hook-wear and to give extra strength.
9. **One-Piece Cast-Steel Housing Cap . . .** provides utmost accessibility to the wash-pipe stuffing box.
10. **Long-Radius Heat-Treated Cast-Steel Gooseneck** — Enlarged fluid passage at bend decreases fluid velocity. This feature combined with long radius, reduces flow-restriction and fluid cutting.

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with files or with shoulder dressing tools. Joints which cannot be repaired in this manner should be reworked in a well-equipped machine shop.

Never switch a damaged pin into an undamaged box or vice versa, as this is most likely to result in increased rather than decreased trouble.

3. Use substantial thread protectors on tool joints when moving pipe, in order to avoid accidental damage to the threads and thus reduce galled or "frozen" pin and box connections.

4. When "breaking in" a new string of joints, it is good practice to tong them up by hand for the first few round-trips and then cathead them up tight. High-speed makeup with the spinning line on new joints is likely to result in galled or "frozen" connections.

5. Use a good quality thread lubricant on tool joint pin and box connections for normal drilling operations. Apply liberally to threads and shoulders, distributing the lubricant thoroughly with the brush. Do not depend upon rotation of the pin in the box during makeup to distribute the lubricant in the connection. The use of a good quality lubricant on tool joint pin and box connections is particularly important when breaking in a new string.

When exceptionally high torque is to be applied to the drill stem, a special lubricant should be used on the tool joints in order to develop a high coefficient of friction in the threads and shoulders, and thus prevent swelled or split-box failures. A lubricant consisting of 1 pound to 2 pounds of red lead per gallon of kerosine has been found satisfactory for this service.

6. Pay particular attention to the condition of the kelly-sub threads and shoulder. The continued use of a damaged kelly sub may seriously injure every box in the string.

7. Avoid forced makeup of improperly engaged threads. This often results in galled "or frozen" tool joint connections.

> 8. Do not mate pins and boxes together which have appreciably different diameters as "fins" may be produced on the shoulders which will prevent proper make up with other tool joints. When new tool joints are added to a string of worn joints, it is best to keep them all together to prevent the mixing of different diameter pins and boxes.

9. Wear on the outer surface of tool joints entails much expense to the operators because, in many territories, it necessitates making several tool joint replacements on the drill pipe. Not much is known that can be done to prevent this, but during recent years considerable has been done in the development of means of reducing this cost as outlined hereinafter.

Rebuilding the outer surface of worn tool joints reduces the number of replacements required. Although the cost of rebuilding the outer surface is less than that of new joints, the service obtained from rebuilt joints in most cases has not equaled that of new joints. Therefore, the economics of this practice can be determined only by a careful cost analysis.

Increased life of tool joints can be obtained by the use of oversize joints. The increase in life to be gained by this method is limited by the maximum tool joint diameter which can be used safely; thus in some of the more abrasive territories this will not be sufficient to eliminate the necessity of making tool joint replacements.

The use of shrunk-on tool joints has reduced the cost of replacing worn joints, and thereby has aided in reducing the overall expense resulting from tool joint wear.

The rate of wear on tool joints actually can be reduced by the use of hard-surfacing. Tungsten carbide seems to be the most suitable material for this purpose, but due to the fact that the material itself and its application to the joint are both expensive, there is at this time some doubt as to the overall economy of this procedure.

> Hard-surfacing of tool joints with tungsten carbide has proved both effective and economical for reducing abrasive wear on new tool joints, especially when large quantities are applied. Certain types of tool joints can be hard surfaced in the field, and their life extended indefinitely by re-application at correct intervals.

A promising development in combating the tool joint wear problem is the use of wear subs between the joints. The principal advantage is that they can be replaced so readily at the rig, but here again only an accurate cost analysis can determine the overall economy of this procedure.

> Operational difficulties with wear subs have caused their use to be almost completely discontinued.

New developments in rubber protectors for use in open hole now are being exploited as a means of preventing excessive wear on tool joints. In the past a big objection to rubber protectors has been the difficulty of keeping them in the proper place on the pipe, and also of preventing them from becoming badly cut and torn when they are run in open hole. If the new developments can overcome these difficulties, it is believed that such protectors may be very beneficial in reducing wear on tool joints.

> As yet, rubber protectors, for use in open holes, have not reached a stage of development to offer practical means for overcoming abrasive wear on tool joints.

Eccentric wear on tool joints is usually due to the operation of crooked pipe, and the remedy, therefore, is obvious. Although instances are known in which eccentric wear has occurred in the pipe and tool joints even though the pipe remained commercially straight, there is no known remedy for this type of wear.

> The use of adequate weight in drill collars to keep all the drill stem in tension will reduce abrasive wear on tool joints.

A point often forgotten is that a drilling string sometimes may be subjected to abuse just in one well, or by just one crew, and later used normally, but in which troubles may continue to develop throughout the rest of its life. A simple example would be where one crew, being very careless in stabbing, damaged a number of the tool joint box shoulders. This could lead to a succession of wabble failures and mud cutting throughout the whole string.

Or, suppose that on just one well old-type table spider slips were used which scarred the pipe with deep transverse slips marks. These marks easily could be the cause of numerous notch-fatigue failures, no matter how carefully the pipe was used thereafter.

The point is that eternal care with a drilling string, as in the case of all material, is the price of trouble-free service. And, actually, as most operators and contractors are learning rapidly, it is really not a high price at all.

Acknowledgement

Acknowledgement is hereby made for helpful suggestions in developing and editing this paper. The authors are particularly indebted to Ralph Neuhaus of Hughes Tool Company, and to D. C. Neely and G. M. Eaton of Spang Chalfant, Inc.; also to other members of these organizations and to operators and contractors throughout the oil fields.

Reference

[2] H. W. Fletcher, "Drill Stem," *Drilling and Production Practice*, American Petroleum Institute, New York, 150 (1935).

Discussion

J. E. Warren (Carl B. King Drilling Company, Midland, Texas.) The Texter-Grant paper is so authoritative and comprehensive that it has attained the position of a standard reference concerning drill pipe and tool joint troubles.

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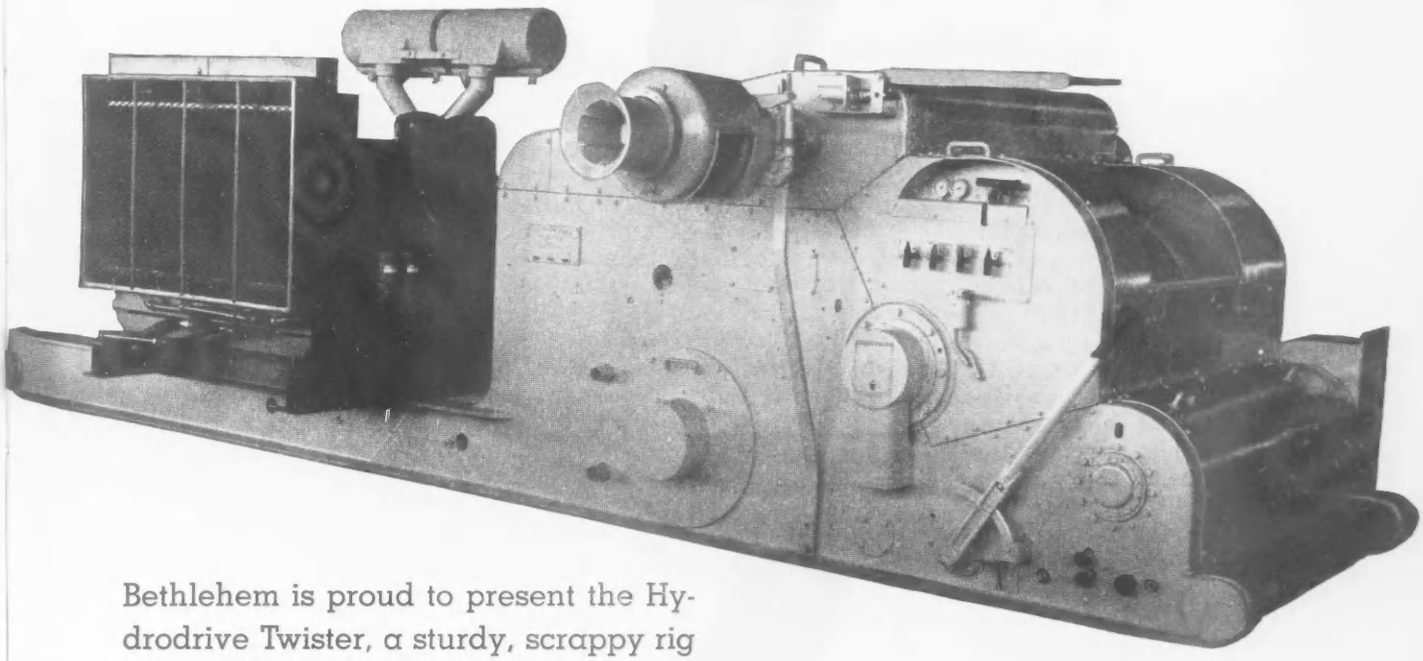

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The authors, through their preparation and revision of this paper, have made a considerable contribution to the art of drilling oil wells. Periodic revisions will be needed as additional experience is gained through new problems and as new methods of drilling are developed.

Heavy weight drilling has made drill collars an increasingly important part of the drill stem; and drill collar problems are intimately related to those affecting drill pipe and tool joint operation. In order for this paper to include all the troubles applicable to drill stem operation, consideration should be given by the authors to a section covering the troubles encountered in the operation of drill collars.

The troubles encountered in drill stem operation vary between different development areas of the United States due to the difference in formation characteristics and drilling conditions. The Permian Basin, being one of the more important drilling areas in the United States, is also an area in which drill stem operation presents a serious problem. Remarkable progress has been made in this area in the reduction of drill stem costs. Most of the improvements can be attributed to heavy weight drilling and the practice of concentrating bit weight in the drill collar section of the drill stem.

The following comparison, based on the experience of one drilling contractor, is given to illustrate the significance of improved practices of drill stem operation in the the Permian Basin. The comparison shows the difference between existing costs and practices followed in 1941 and 1948 for two 12,000 foot strings of drill stem operated under comparable conditions.

Twelve thousand feet of drill stem, consisting of Grade E 16.60-pound drill pipe, flash weld hard faced tool joints and twenty 6¼-inch drill collars, represents an investment of $66,500.00 at today's cost F.O.B. Odessa, Texas.

Twelve thousand feet of drill stem, consisting of Grade E 16.60-pound pipe, full hole tool joints and three 6¼-inch O.D. drill collars cost $32,285.00 in 1941.

It is apparent the drill stem investment required to drill wells efficiently in 1948 is twice the amount that was considered necessary in 1941.

The relative importance, from an investment standpoint, between tool joints, drill pipe and drill collars has changed materially in the past eight years. This relationship is shown as follows:

PERCENTAGE OF DRILL STEM INVESTMENT 12,000 FOOT STRING 4½ INCH

	1941	1948
Drill Pipe	46.7%	29%
Tool Joints	47.0%	43%
Drill Collars	6.3%	28%

The above comparisons are based on initial investments only; and since maintenance and salvage varies between tool joints, drill pipe and drill collars, the following estimate has been made of drill stem costs. These estimates compare the actual experience of a string retired in 1948 that drilled 70,000 feet of hole and a hypothetical string in 1941 that was retired after 35,000 feet of hole had been drilled. Thirty-five thousand feet of hole for deep drilling was considered exceptional service in 1941.

Drill Pipe Service	1941 35,000′	1948 70,000′
Initial Cost	$15,061.80	$19,400.20
Operation	.....	2,000.00
Total Cost	$15,061.80	$21,400.20
Less Salvage*	3,390.00	5,499.50
NET COST	$11,671.80	$15,950.70
Tool Joints	$14,916.00	$28,425.60
Less Salvage	186.00	11,382.80†
NET COST	$14,730.00	$17,032.80
Drill Collars	$ 2,073.00	$18,634.00
Operation	250.00	7,000.00
Total Cost	$ 2,323.00	$25,634.00
Less Salvage	250.00	3,726.80
NET COST	$2,073.00	$21,907.20
TOTAL COST DRILL STEM	$28,474.00	$54,890.70

* Thirty cents per foot salvage on retired pipe used in 1941 and fifty cents per foot used in 1948. Due to extreme shortage of line pipe in 1948, retired 4½" drill pipe sold as high as one dollar per foot, but fifty cents per foot is considered nearer the intrinsic value for service comparisons.

† Tool joint service has been increased so that joints can be applied to second string of pipe after first string has been retired.

PERCENTAGE IN FOOTAGE COST COMPARISONS 1941 vs 1948

	Cost per Foot Drilled		Percentage of Total Cost	
	1941	1948	1941	1948
Drill Pipe	33.3¢	22.8¢	41%	29%
Tool Joints	42.1¢	24.3¢	52%	31%
Drill Collars	5.9¢	31.3¢	7%	40%
TOTAL	81.3¢	78.4¢	100%	100%

These comparisons illustrate the progress made in drill stem operation for Permian Basin deep drilling. The basic theory of concentrating bit weight in the drill collar section and maintaining drill pipe in a state of tension was well recognized long before 1941. It was considered, however, that operational and mechanical problems encountered in maintaining long multiple drill collar sections would be more costly and hazardous than running drill pipe in compression. Slower rotation of drill pipe, better drill collar joint design and greater care in handling overcame the earlier objections and the practice of using multiple drill collar sections is now standard.

Some of the conclusions that can logically be made are as follows:

1. That the drilled footage life of drill pipe has been doubled.
2. That hard surfacing of tool joints, better lubricants, higher makeup torques, and drill pipe run in tension have increased the footage drilled life of tool joints four times that experienced eight years ago.
3. That drill collars are of increasing significance in the operation of drill stem. The cost of replacement and maintenance being higher than either that of drill pipe or tool joints.
4. The investment in drill stem has been doubled for 12,000′ in the past eight years. This can be attributed to two reasons:

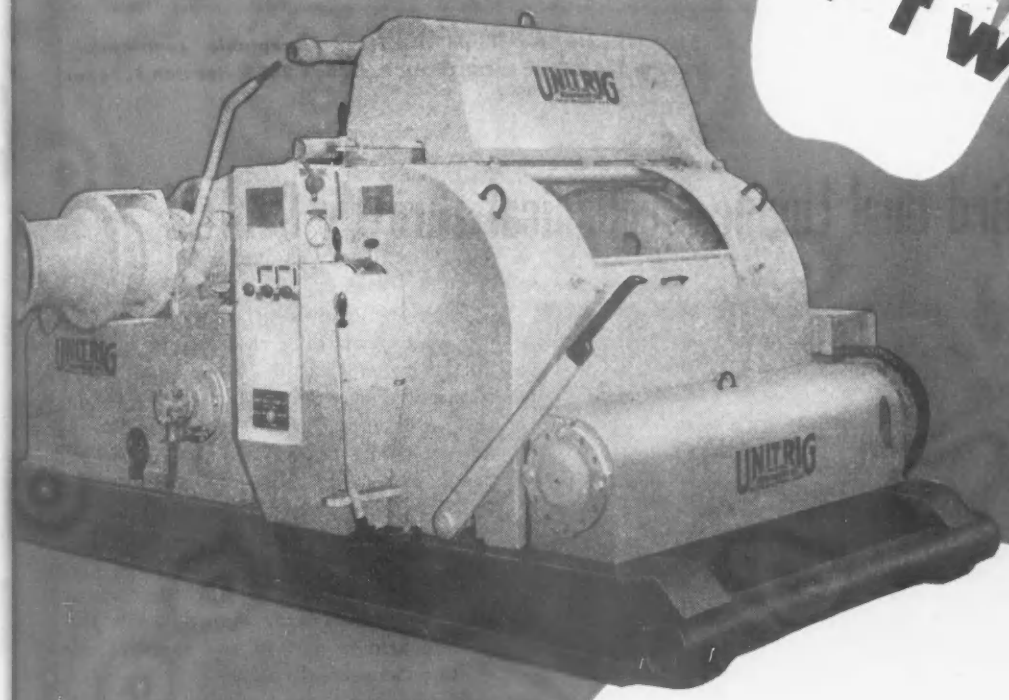
(a) Approximately thirty to forty percent inflation in material prices, and

(b) The need of long drill collar sections to meet the requirements of heavy weight drilling practices.

5. That the increased investment in drill stem has been fully absorbed by increased service obtained through more efficient drilling practices and improved design of drill stem.

[Series concluded]

FOR THE MAN WITH ONLY TWO HANDS...



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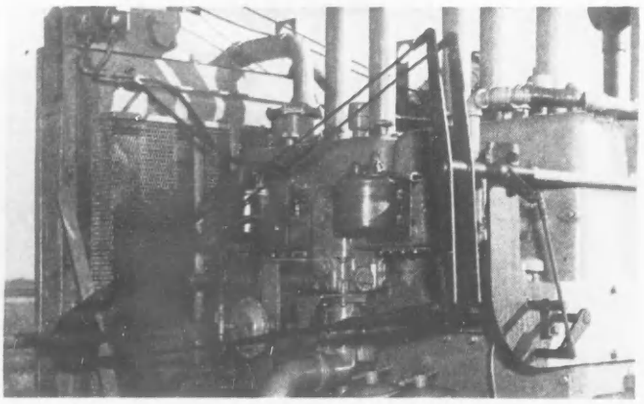
HOW TO—Add Simplified Dual Engine Mechanical Throttle Control

On workover and shallow-depth power rigs, a simplified mechanical throttle control has provided a positive, smooth-acting method of controlling speed of either or both of dual engines. It has the advantage of being simplified and its design permits extremely close control over speed.



Two throttle wheels are mounted at the driller's position on the drawworks. One wheel is connected to an outer hollow shaft, and a smaller wheel connected to a smaller shaft fitting inside the larger one. These shafts terminate at the engines in a bearing socket as shown.

A sprocket has been welded to the outer shaft and one welded to the exposed inner shaft. The inner shaft serves as an axle on which the outer shaft rotates. Each sprocket is independent of the other and each can be moved without changing the position of the other.

Each sprocket is fitted with a three-foot section of roller chain which is connected to steel cables. The cables are terminated on the under side by coil springs included in the system to maintain constant tension in the cable and chain. The cable controls are connected to actuating arms which transfer the horizontal motion into vertical motion by means of rods attached to the arms. The inside arm is part of the throttle control system on the engine shown, while the outside arm is part of the system controlling the second engine.

A right-angle arm has been made from steel plate and bolted to the engine block. This arm serves as a base for the other motion transfer linkages shown. On this base have been included the limit stops of the throttle control. The device is efficient and due to simplicity is easily repaired by crewmen in the event of difficulty.

HOW TO—Adjust Space Between Pump and Driving Engine

Due to the bulk and weight of large power-driven mud pumps, it is necessary to provide some means to adjust the proper spacing between the pump and the driving engine. Replacing the somewhat common screw spacer are the building jacks shown. Not only do these jacks provide adequate strength, but adjustments can be made over a distance of about 18 inches, thereby allowing considerable flexibility in pump-to-engine setting.

The large power-driven mud pump is conventionally-mounted on I-beam skids which are tied together at each end in the usual manner with a heavy piece of four-inch pipe. The pump is located on the ground to the rear of the drawworks, which are mounted on the elevated substructure. Instead of placing the pump skid on a timber mat, a framework of I-beams serves as the foundation for both the main pump and the auxiliary pump. The foundation butts up against the substructure, supporting the engine and power take-off for the pumps and drawworks.

I-beam abutments shaped as shown

have been welded to the steel framework foundation so that the base of both jacks will rest on the vertical surfaces. A semi-circular cap was welded to the abutment pieces in order to support the jack bases. Half-rounds made to fit the four-inch cross piece on the pump skid base were welded to the top of each jack so they will not fall out of place in the event pump moves away from the jacks.

Once in place, the pump can be pushed the proper distance from the sub-structure by inserting a bar in the head holes of the jack and screwing the shank to the right, thereby extending the jack. Because of the heavy square threads on the jack, vibration does not tend to unscrew them.

Harmony over Texas Tidelands . . . . . .

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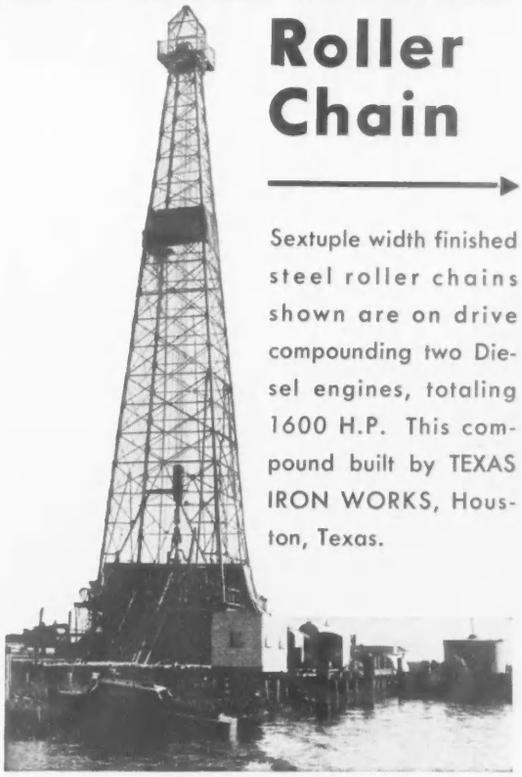
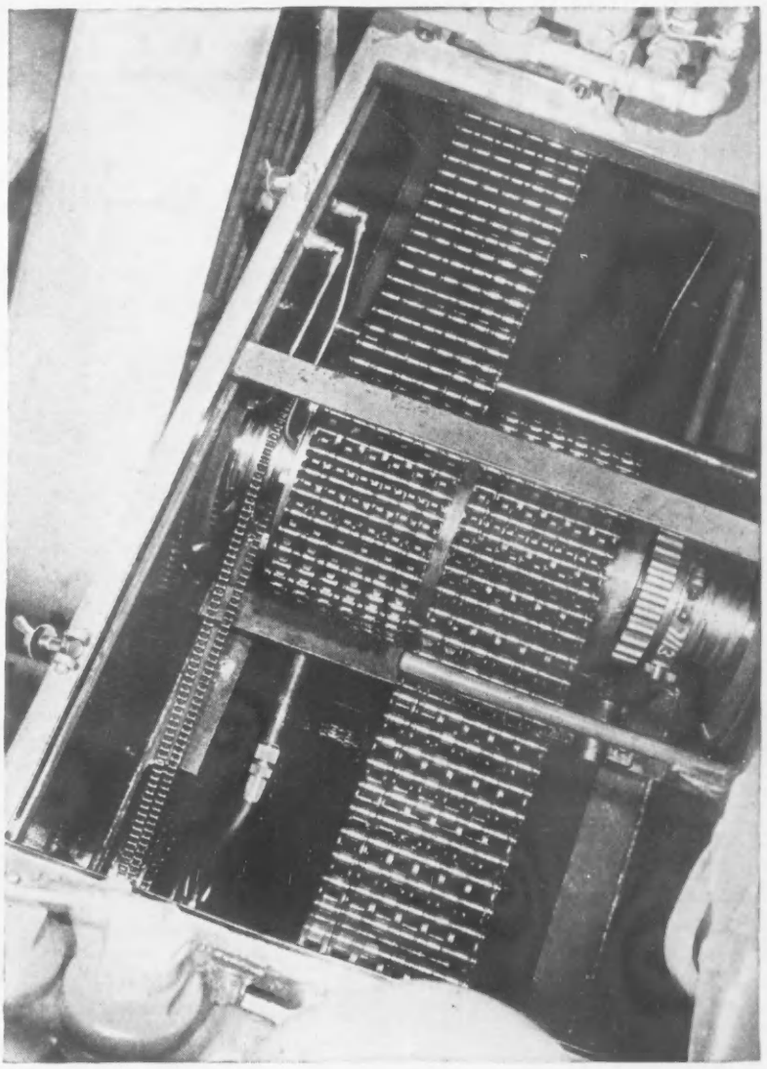


Sextuple width finished steel roller chains shown are on drive compounding two Diesel engines, totaling 1600 H.P. This compound built by TEXAS IRON WORKS, Houston, Texas.



Here's one of Otis W. Dyer, Jr.'s rigs, equipped with Link-Belt finished steel roller chain. It's drilling at 8021 feet, out in the isolated marshlands of the Texas Gulf Coast. Set on pilings, supplied only by a 13-mile boat trip, this is no place for costly breakdowns!

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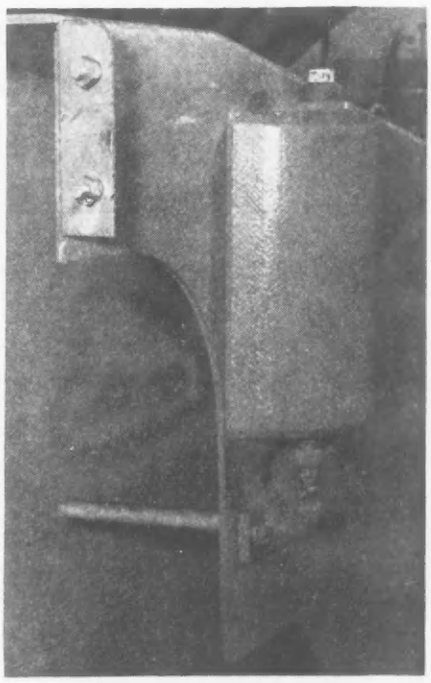
HOW TO—Simplify Rotary Chain Lubrication



Proper lubrication of the rotary chain is essential to peak performance and long life. Many devices have been used, most of such lubricators having been mounted on the rotary chain guard so the lubricating oil would flow by gravity onto the chain.

Illustrated is a well-constructed, efficient rotary chain lubricator that is an integral part of the chain guard. Instead of allowing the oil to flow on the upper section of the chain, this particular design permits the oil to flow on the lower section of the chain as it is pulled onto the driving sprocket.

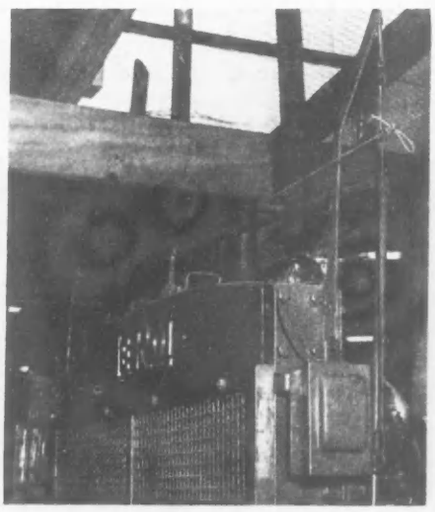
It consists essentially of a 12-inch section of eight-inch casing split in half and welded to the chain guard as shown. Piping to the bottom is connected through a petcock to a horizontal perforated nipple made from three-quarter inch pipe. The horizontal member is secured to the chain guard by a heavy piece of strap steel which is welded to the nipple and bolted to the chain guard.

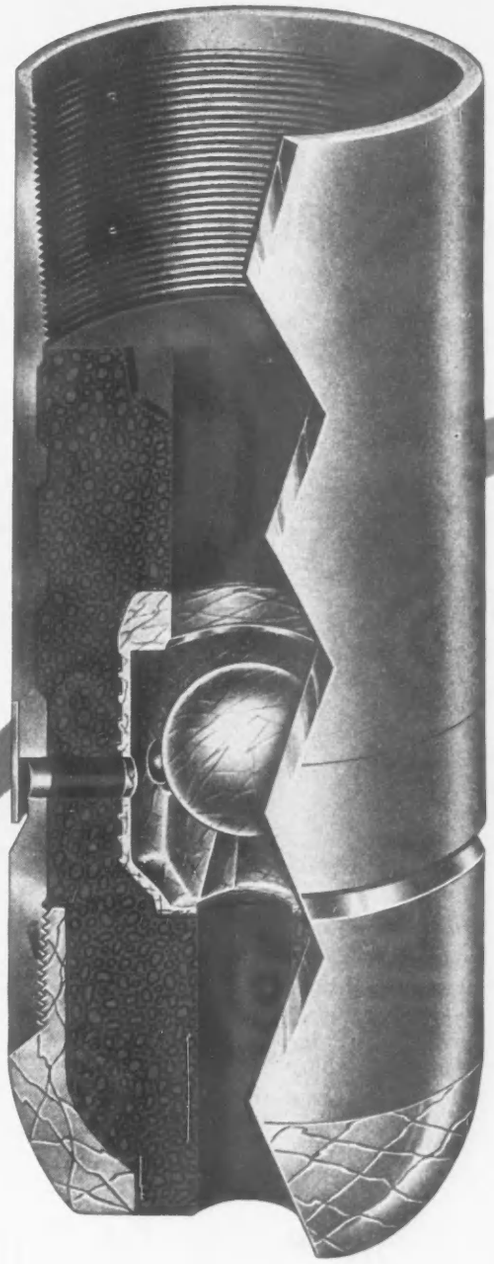
Top of the half section of casing is welded closed except for a two-inch opening fitted with a plug. Lubricating oil is added through this opening during each tour to insure an adequate supply during the eight-hour shift. Flow of oil is regulated by the small petcock at such a rate as to provide ample oil for the chain.

HOW TO—Fabricate Engine Cutoff System

A cutoff system which will simultaneously shut down a bank of multi-cylinder engines on a drilling rig by actuating switches on each of the units is employed by a drilling company in California. On the side of each engine radiator shell is mounted a small conventional switch box, it being installed in such a way that when the engine is running the cutoff handle is in the down position. Mounted above each box is a flat steel bracket, from the top of which is suspended a small pulley. Over this pulley is run a short cord, one end of which is tied to the switch handle and the other to the main jerk line. The latter extends down the row of engines, and is actuated by the driller from his position beside the drawworks.

The switch, wired in series with the ignition system, is fully enclosed, and for this reason can be depended upon to function in an emergency even though water, mud or oil may have been splashed over the engines. The system is easy and economical to install, and for the greater part is easily salvageable for use on other engines.





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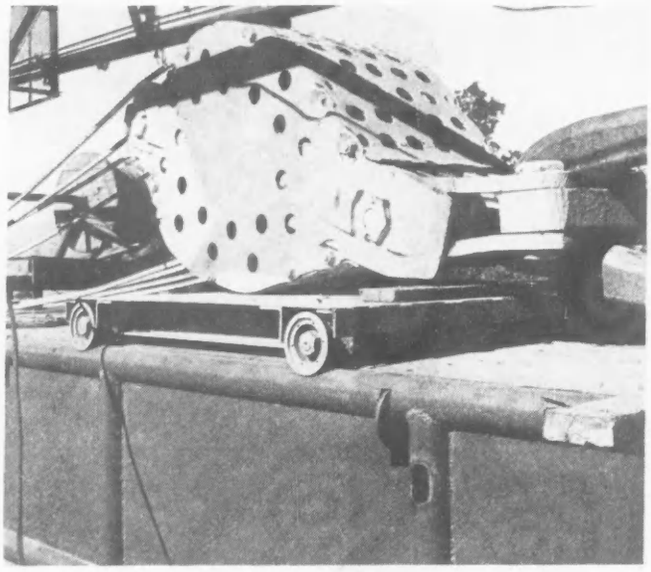
HOW TO—Handle Heavy Drilling Equipment



An ingenious method by which the traveling block and other small but very heavy objects easily can be loaded and unloaded from the derrick floor or pipe rack is contained in the idea developed by one drilling company. A low-bed, four-wheel dolly, sturdily made of heavy structural steel and angle iron material, and mounted on heavy axles, was made to run along the top two rails of the skid-mounted walkway. The wheels, having concave wheel surfaces, conform to the curved surface of the rails, the latter being made of salvaged drill pipe. Deck of the dolly is made of steel plate and is amply strong to support the heavy weights placed upon it. Once loaded, the dolly is easily pulled along the walk for easy truck-height loading. When not in use, the dolly may be lifted off and laid to one side, little room being required for its storage.

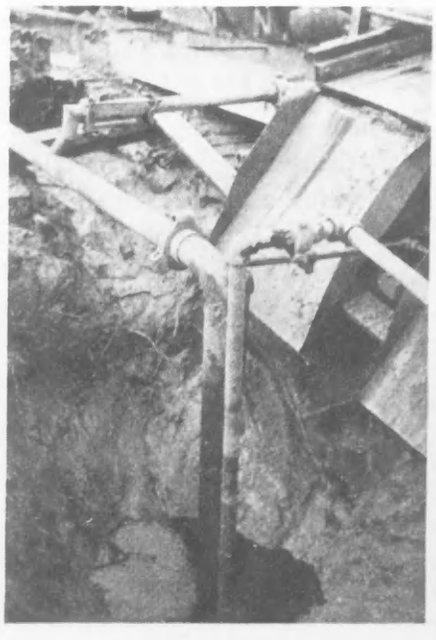
The dolly may be built to fit any dimensions existing on a rig, either for moving along the walkway, or any part of a rack adjoining the rig.

HOW TO—Facilitate Moving Jet Cuttings

By welding the exhaust line from the turbine driving the shale shaker into the pipe used to convey jetted cuttings from the pit under the screens, one company makes one run of three-inch pipe serve a dual purpose, and by just that much reduces the amount of pipe required for rigging up.

By piping the turbine exhaust steam into the jet line it is kept open at all times, and warmed enough so that any oil picked up by the jet does not congeal and form a nucleus for a bridge or obstruction within the pipe.

Carrying the exhaust steam from the turbine out to the waste pit at the end of the cuttings line also removes the steam from the vicinity of the working area, increasing visibility and eliminating the slippery area frequently encountered when steam condenses on planking near the shaker.



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HOW TO—
Store Reserve Drilling Mud at Well Site

In drilling wildcat wells, semi-wildcat wells and even extension wells, it is desirable to have a ready supply of drilling mud in case unforeseen subsurface conditions require additional drilling fluid. In many instances, the reserve mud pit is a precautionary measure to meet emergencies created by lost circulation, blow outs, etc. Normally, mud is transferred from the reserve pit to the pump sumps by the auxiliary mud pump which has relatively limited capacity. As drilling progresses, additional fluid must be added to the system, and can be made up from the reserve pit through the auxiliary pump. However, if it suddenly becomes necessary to supply the mud pumps with volumes considerably larger than those within the capacity of the auxiliary pump, other means must be employed to transfer the fluid.

Meeting the above requirements in all situations, and yet eliminating the need of a transfer pump, is the rectangular, upright steel mud tank illustrated. Measuring approximately six-by-six feet on bottom and nearly 18 feet from the ground to the top edge, this reserve mud tank is of an adequate volume to meet most emergency needs, as well as those of normal drilling. In use, the tank is open at the top and sufficient hydrostatic head pressure exists when the tank is nearly full to fill the mud sump pits in a matter of minutes by opening the large discharge valve.

The tank is constructed of an angle iron frame to which has been welded sheet iron. An elevated platform was made from three-inch pipe, and permanently welded to an I-beam skid shown on the right hand edges of the tank. When empty, the tank is transported from location to location by lowering it to a horizontal position and loading the unit on a truck.

HOW TO—Enclose Pump Engine Radiator Fan

On pumping wells which are located in areas where tampering may be expected from passers-by, the danger always exists of someone inserting a stick or a hand into the radiator fan, with possible personal injury, and damage to fan blades and radiator core. One company perfected a simple form of screen enclosure. Easily made in the shop, it is easily installed or removed, and represents very little in cost of materials. Made in two equal sections, one for each side of the engine, the screen is of expanded metal bent at right angles at the side to form a box-like enclosure. Holding the screen in place are three small L-shaped hooks which are welded to the screen and which hook over small eye-brackets, two of the latter being welded to the side of the radiator shell and the other being attached to the fan pulley post. By lifting up the screen an inch or so and leaning it back and outward, the screen sections are easily removed when it is necessary to gain access to that part of the engine. Presence of the screen also prevents windborne trash and debris from becoming entangled in the blades, making servicing work an easier job.

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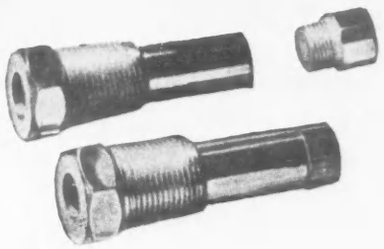

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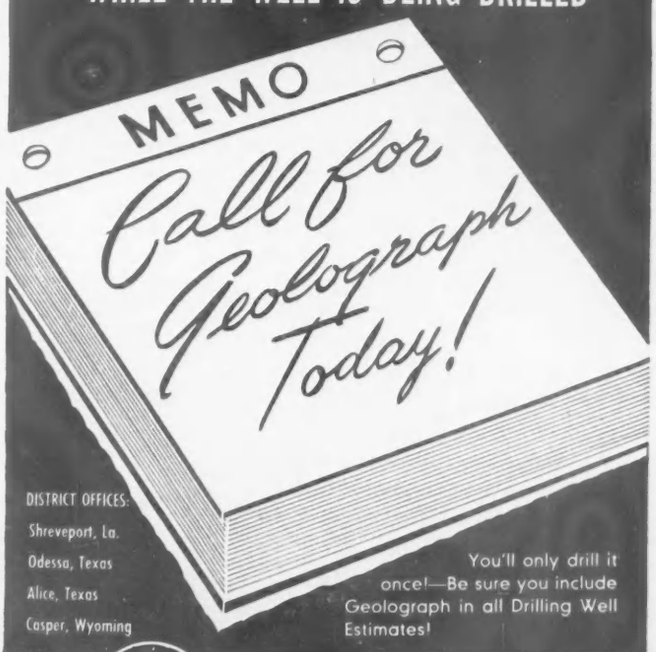

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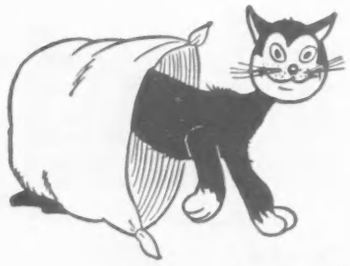

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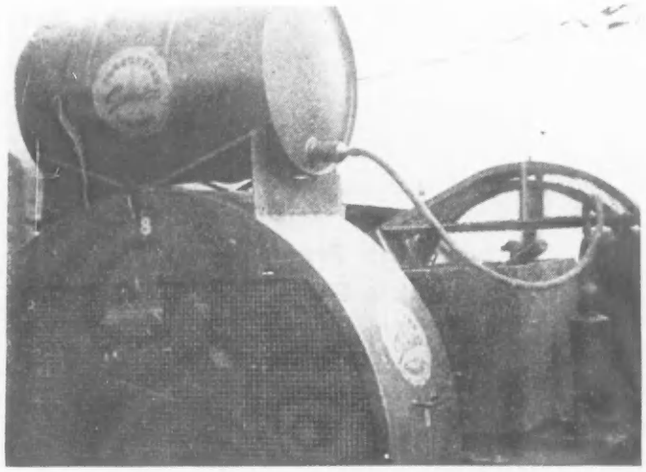
HOW TO—Mount Piston Rod Lubricator



A simple method of supplying lubricating oil to the packing glands of the fluid ends of mud pumps was easily devised by one company by mounting a drum on the belt guard which covers the pulley wheel, and connecting the outlet to the lines which lead to the piston rod connections. Another drum (not shown) is placed beneath the pump so that the oil will gravitate into it. The upper drum is filled with diesel oil or other light oil which will provide a cleaning action as well as lubrication, and the sight feed lubricator jets are set so as to almost empty the upper drum during one shift.

At the beginning of each tour, the entire contents of the lower drum are drained and the oil decanted from the water and mud which comes from the packing glands. The oil is replaced in the upper drum and the water and mud discarded.

This method, although manual, provides plenty of clean oil at all times for the piston rods, yet the packing glands may be allowed to remain loose enough to prevent danger of galling, and the leakage easily discarded.

HOW TO—Provide Shelves in Change House

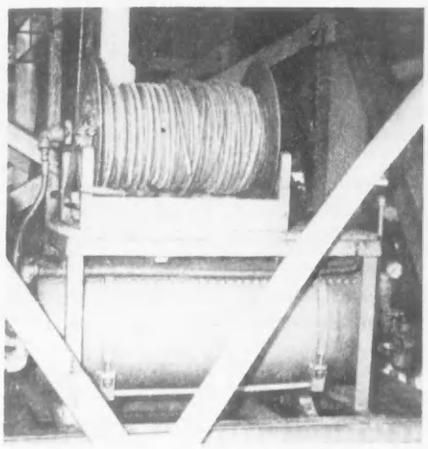
For the convenience of workmen in the change house, one company provides a number of collapsible shelves which are permanently attached to the doors of the lockers. Every other locker is fitted with one of the shelves. Made of light sheet metal and having a rolled-over edge for added strength and improved appearance, the shelf is hinged to the front of the door so that when not in use it can be dropped down almost flush with that surface. A triangular piece of sheet metal hinged to the underside of the shelf is let down to support the shelf in the manner shown in the photograph. A strip of flat steel welded or riveted across the front of the door at the point where the triangular support member would contact the door surface gives added strength at that point and prevents possible caving in or denting of the sheet metal surface. Among other uses, the shelves provide convenient places on which to place lunch boxes at meal times, and a handy shelf on which belongings can be deposited while clothes are being changed.

DRILLING HINTS

HOW TO—

Handle Air Hose

Instead of the usual hook or bracket on the substructure which most companies employ as a storage point for the air hose used for odd jobs around the rig, one company provides a compact reel and air receiver unit. It is mounted within the substructure at a point where the hose may be strung out



equally well for rig floor work or for painting the mud pumps and other scattered equipment.

The reel is fitted with a packed joint so that air is brought into the shaft and thence to the hose, so that only one connection—that to the tool being used—is required. A shutoff valve at the receiver enables the hose to be bled free of pressure when not in use.

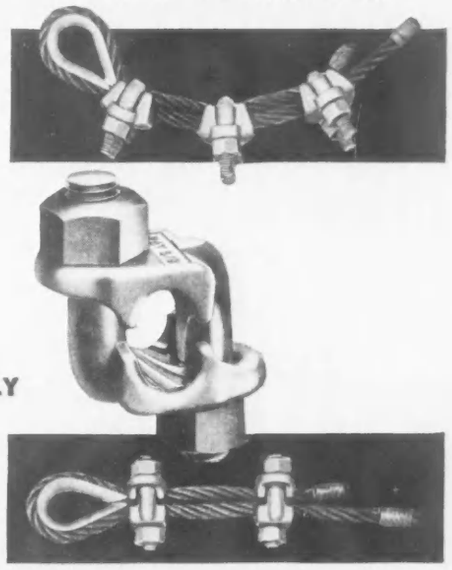
A detachable crank, geared to one end of the reel through a pair of bevel gears, permits the hose to be rewound and the spooling watched at the same time, one hand serving to turn the crank while the other guides the hose across the drum.

HOW TO—

Adjust V-Belt Tension

V-belt life can be appreciably extended provided the proper tension is maintained. The right amount of belt tension will not only prevent slipping, but will eliminate whipping on the slack side of the system. To insure an optimum amount of tension in the V-belt drive takeoff between the drawworks engine and the main mud pumps, one contractor fabricated an idler that automatically adjusts V-belt tension even though the distance between sheaves

AVOID THE "FINGER-PINCH"



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DRILLING HINTS

varies from one location to another, and even during operation.

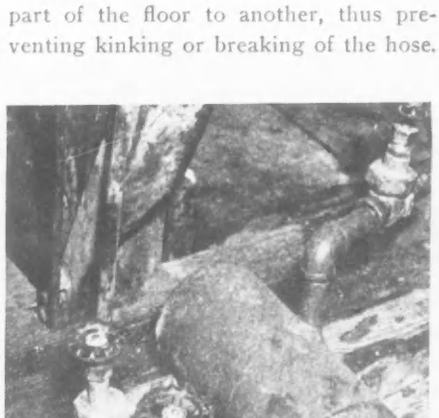
The idler illustrated takes advantage of leverage in providing the right amount of tension in the V-belts used to drive the mud pump. It consists of a polished steel roller approximately six inches in diameter and 24 inches long. It is mounted on roller bearings on the short arm of a cradle made from angle iron. The cradle is pivoted by two bearing joints as shown, with a pan made into the long arm of the cradle. The idler is supported on an A-frame assembly made from angle iron and welded to a flat steel plate base. This base was welded to steel spacers which prevented the pump from creeping toward the driving sheave during operation.

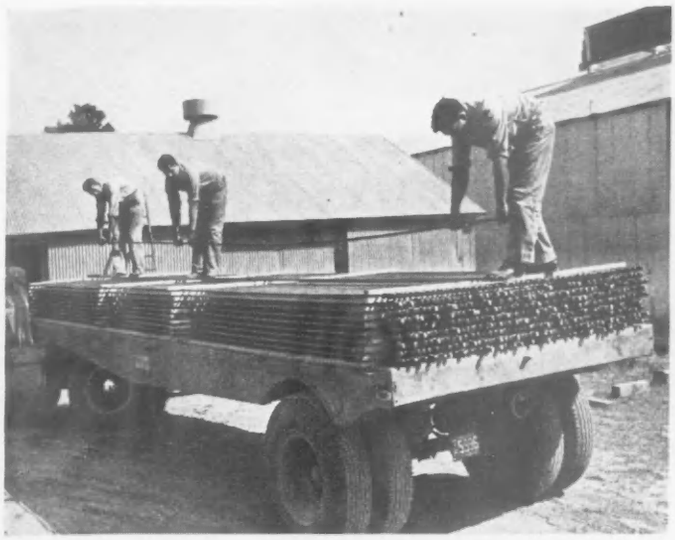
Tension on the V-belts can be carefully adjusted by adding or removing weights in the tray of the idler cradle. In the illustration, the fulcrum arm is long enough to provide sufficient belt tension without the use of additional weight in the tray. The device is relatively simple, and has been in satisfactory service for a number of years. Increased life and performance from V-belts has resulted, and being somewhat automatic, little attention is required.

HOW TO—Make Water-Steam Mixing Chamber

While drilling with oil-base types of mud, or during the process of completing a well, the derrick floor and most of the equipment in the immediate vicinity become covered or at least splashed with the slippery oil and mud, with consequent danger to personnel. Hosing down with cold water does not do a very good job of clearing away the material, and in addition, usually involves a considerable amount of time. One company found that installation of a small mixing chamber in which water and steam could be thoroughly mixed provided a simplified and more efficient means of cleaning floors and equipment. The chamber used is a small cylinder made by welding circular plates over the two ends of a short length of seven-inch casing, the unit being mounted on a base consisting of two short lengths of angle iron. One-inch water and steam lines, each fitted with a valve for close adjusting of the volume or proportions desired, are welded into the bottom of the chamber. The single outlet line, to which may be attached a hose, is welded on the upper and opposite side. As can be seen in the photograph, the lines are welded in tangentially to the surface of the cylinder, these positions assuring that a rotary motion will be imparted to the steam and water, with consequent improvement in the mixing.

The complete unit takes up little space and may be installed in any little-used part of the derrick enclosure. Once the inlet lines are positioned and hooked up, the unit may be spiked down to the floor through small holes burned through the angle base members. It is as easily lifted up and carried when the rig is torn down. By allowing a slightly loose fit on the elbow in the outlet side, the valve and fittings may be made to swing as the hose is moved from one part of the floor to another, thus preventing kinking or breaking of the hose.





In unloading rods from truck, never drop them; lift them off individually and lay them down easily. Note third man in center to support rod. Bends caused by dropping from truck or other careless handling cause concentration of stress at the smaller radius of the bend, resulting in early failure of rod.

Care and Use of Sucker Rods

EMPHASIZING the severe service conditions imposed on sucker rods, the author cites elementary methods in handling, running and operating which will add much to rod life and reduce possibility of functional failure. Correction of careless handling is especially urged, as damage here can provide focus for future stress concentration and ultimate break.

By JOHN S. FULLER
Manager Production Equipment Sales, Oil Well Supply Company, Dallas

SUCKER rods are operated in nearly 400,000 wells in U. S. oil fields. The average depth of pumping wells is approaching 3000 feet, indicating that if all sucker rods in operation in the U. S. were placed in a single string, it would extend around the world between nine and ten times. At 20 cents per foot the value of these rods comes to nearly $250 million, no small sum, even in an industry having billions invested. The care and proper use of sucker rods is imperative.

The earliest rods were made of wood with iron box and pin joints which were riveted to the rods in much the same manner as the common shovel is attached to its handle. The wood rods, which were used in the earliest pumping wells and to which the term "sucker rod" was applied from the start, were usually of one inch diameter. By 1900 wooden rods varied in sizes up to 3½ inches in diameter, and box and pin joints for welding to small diameter pipe or solid steel rods made their appearance. By 1904 steel and wrought iron rods with integral pin and box were available. By 1910 the present appearance of box and pin rods was established and by 1913 the "California" double pin with coupler rods was being manufactured.

The first world war gave great impetus to metallurgy. The loads that could be applied to rods of a given size began to climb. The true nature of fatigue (then called "crystallization") was studied and research laboratories pointed the way to the use of alloy steels and to full heat treatment. The pace of improvement has accelerated since that time, highlighted by new steels, new heat treatments, new cleaning methods, new finishes, better gauging, automatic threading, thread protectors, inside covered storage for protection, rigid inspection, and better handling throughout.

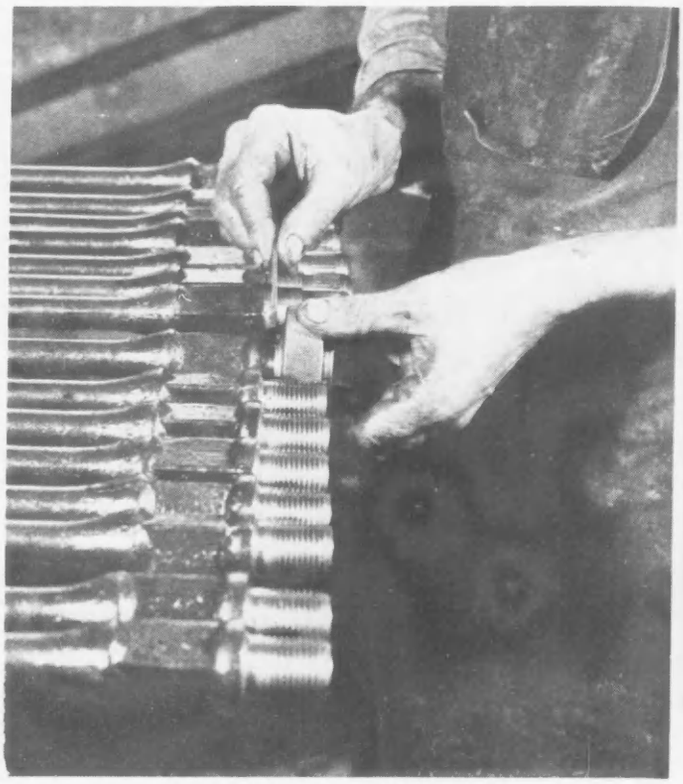
Specialized laboratory and field equipment includes well weighing devices, photomicrograph equipment, impact testers, thread comparators, fatigue machines to test rod specimens in actual or standard synthetic well fluids; also, the American Petroleum Institute has established close dimensional standards and improved gauging practice which, in addition to insuring quality manufacture, provides for interchangeability.

As deeper wells are pumped, rods of higher tensile strength are required. This condition is being met through the use of alloys and special heat treatment. The depth to which rods have been used successfully now exceeds 11,000 feet and with the advent of long stroke, slower speed pumping units, greater depths become possible.

Research on corrosion problems, temperature difficulties and similar matters is constantly being carried on by large staffs of specialists devoting their talents to these problems.

The value of metallurgy, meticulous manufacture and gauging, inspection, protection and care in shipment can easily be lost by careless handling of the product after delivery to the customer. Contract pulling crews are usually skilled, trained and conscientious, but a few have inexperienced men, or little supervision, or have fallen into habits of handling which are short of desirable and which causes premature rod failures.

The importance of better handling and storage of sucker rods cannot be overemphasized. It is not the cost of a broken rod but the damage to the remainder of the string and the cost of pulling jobs



LEFT: In hauling, rods should be well supported on at least four stringers and protected against damage from boomers. The slightest abrasion may bring a concentration of stress at that point which could eventually cause a break. Truck with a long float bed should be used, as a bend made by overhang in hauling may result in similar damage.

RIGHT: The feeler or paddle gauge determines compliance with API specifications for sucker rod pin thread vanishing angle and insures square and full make-up with couplings.

that become important. Loss of production, more crews and machines, and inevitably high lifting costs are the price of carelessness.

Few items of oil field equipment are operated at lower factors of safety than are sucker rods. Rods with 60,000 pounds per square inch yield strength are recommended for 29,000 - 30,000 pounds per square inch leads. This is necessary to reduce rod weights in total strings and make possible minimum surface equipment, less counterbalance weight and less over-all cost. If a 5000-foot well is reduced to a scale model ten feet high, then three-fourths-inch rods (normally used in the well) would be 1½ thousandths of an inch in diameter, in our model. This is less than the thickness of a human hair. Reducing load to scale, the weight on the model would be 25 pounds. This illustrates the big job that the little rods are called upon to perform.

Few would care to walk under a concrete block 5 feet long, 5 feet wide and 4 feet thick if it were suspended by one three-fourths-inch bolt. This represents the weight supported by a sucker rod string three-fourths-inch in diameter in a 5000-foot oil well. We certainly would not if it were moving up and down, say 15 strokes a minute with a 64-inch stroke.

A single nick caused by dropping a rod or striking it with a sharp edge can greatly reduce its ability to carry load. First, it reduces the area of the rod at the nick. Secondly, it causes a concentration of stress at the nick and this stress deepens the nick slowly. A progressive crack moves across the rod, further reducing the area, until a break occurs.

A rod bent by unsupported overhang in hauling or by jerking into the derrick or dropping from a truck will likewise cause a concentration of stress in the smaller radius of the bend. This, in turn, results in early failure.

Rust on rods, a symptom of corrosion, means reduction of area and increased susceptibility to fatigue which may cause early failure.

The following rules for proper handling and use of sucker rods should be rigidly followed. The accompanying photographs illustrate good handling practice.

SELECTION: Specify the best rod for the job after calculating loads and investigating well conditions to assure rods working within their limits.

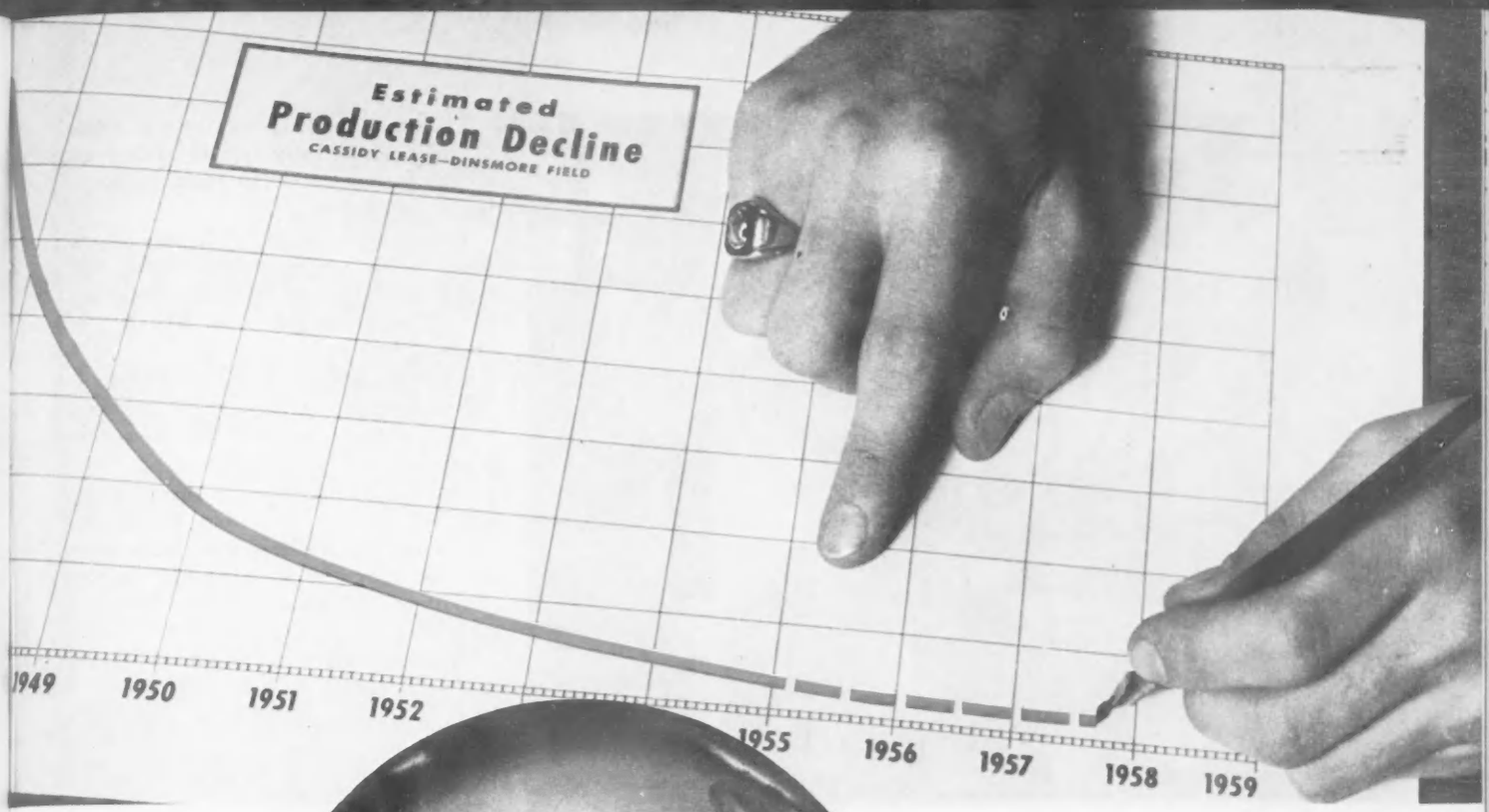
STORAGE: Use wooden skids from car to truck and truck to storage rack. Store rods off the ground, on at least four evenly spaced wooden stringers to prevent sagging and contact with dirt and moisture. Space rods for ventilation. Store rods where vegetation and moisture are avoided.

Do not remove thread protectors until rods are ready to be made up.

Protect rods from the weather to pre-

About the Author

JOHN S. FULLER graduated from Southwestern College at Winfield, Kansas, in 1922 with a B.S. degree and two years later received a B.S. in Chemical Engineering at Kansas State College. For the next four years he was chief engineer for Sonner Burner Company at Winfield and then was gas engineer for the Indian Territory Illuminating Oil Company at Oklahoma City for three years. He joined Oil Well Supply Company, U. S. Steel subsidiary, in 1932 as a sales engineer at Tulsa, and transferred to similar duties at the company's world headquarters at Dallas in 1937. In May, 1944, he was made division engineer for "Oilwell's" Central Midwest Division, and since November, 1946, has been manager of production equipment sales.



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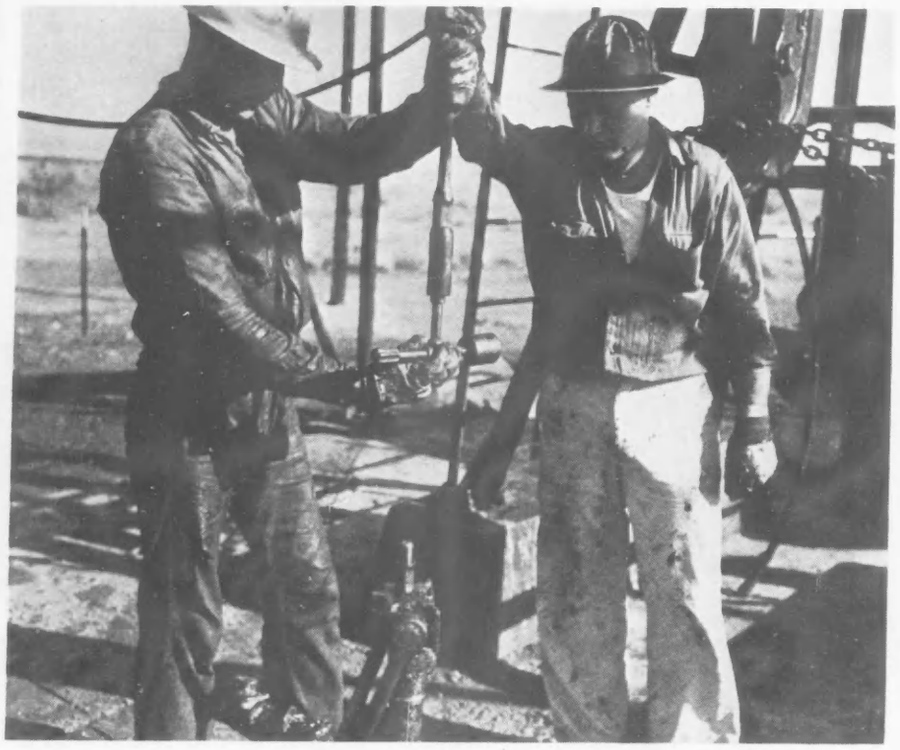


When cross threading occurs in making up, back off joint, run die over pin and tap into coupling to straighten threads. If joints don't shoulder they are dirty, cross-threaded or defective and should be broken and checked.

vent rusting. Store inside buildings wherever possible.

Paint or oil rods regularly if stored for long periods.

TRANSPORTATION: Remove freight car bulkhead with pinch bar. In hauling rods be sure that they are supported adequately on at least four stringers and are not damaged by boomers. Use truck with a long float bed.

Never drop rods off a truck; lift them off the truck and lay them down. Use at least three men.

Observe good storage procedure on location, racking rods where possibility of their being damaged by trucks or heavy equipment is remote.

RUNNING AND PULLING: Remove loosened protectors of new rods in the derrick or the mast and not before. Threads should be thoroughly cleaned anad lubricated before making up joints. Box washing equipment is recommended.

Use a zinc-base thread lubricant for best results. Keep slack out of rods while stabbing.

If cross-threading occurs, back off joint, run die over pin, and tap into coupling to straighten threads. Re-clean and lubricate joint before attempting another makeup. If joints do not shoulder when making up, they are dirty, cross-threaded or defective and joint should be broken and checked. Do not run in hole unless rods shoulder properly. Keep elevator shoulder smooth and clean. On new rods, makeup tightly, break joint one turn and retighten. It will be much tighter than at first.

Do not hammer couplings to break joints. They are hardened and will crack. Snapup wrenches should be used in making and breaking joints. A kinked or nicked rod is permanently damaged. Replace the rod and avoid a fishing job. Cold straightening a kinked rod does not repair the damage.

Excessive pulling to free a stuck plunger permanently injures rods even though it may not break them. It is better to pull tubing.

Wherever possible, rods should be hung in the derrick rather than laid down. If rods must be laid down, they should be protected from dirt or mechanical injury.

GOOD PUMPING PRACTICE: Pump wells no faster than is necessary to get production. Slow speeds reduce loads.

Use the smallest size sub-surface pump that will get the production; the smaller the pump the less the load. Keep tools, derrick floor and all equipment in safe condition and clean. Train crews and they will be needed less often.

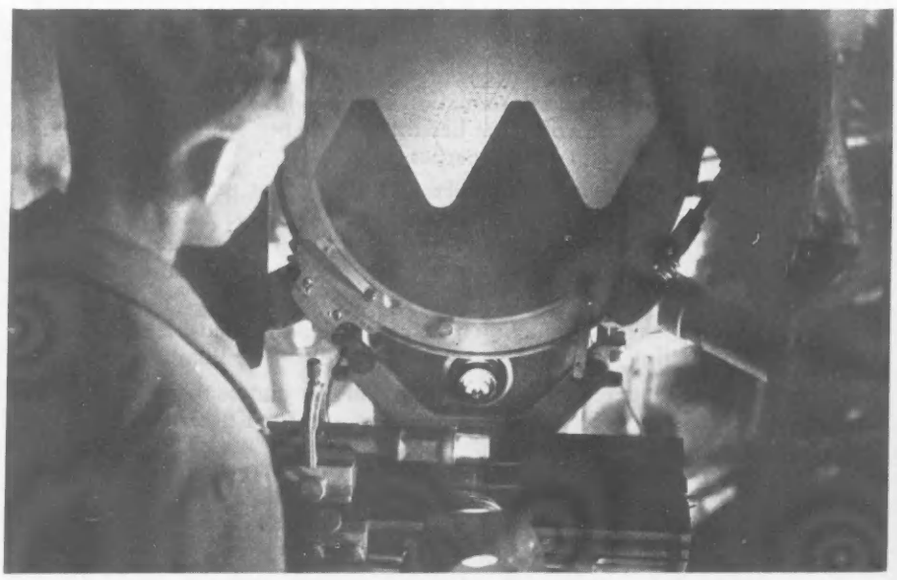
Accurate counterbalancing on pumping units results in longer rod life.

In wells that are hard on rods, use a combination string; for example, the lower two-thirds of the string consisting of three-fourths-inch rods and the top one-third of seven-eighths-inch rods.

Make certain that the pump assembly is fitted properly to avoid excessive friction. A sticking plunger may cause buckling of the rods on the downstroke and thus lead to early failures.

In conclusion, check loads and well conditions before sending rods to the well. Keep accurate histories of each well and the service of each rod string. Check on the crew methods. Keep equipment in repair. Check on counterbalance periodically as well fluid levels and conditions change from time to time.

Remember that sucker rods are highly specialized tools. They can be made to perform long and well when given proper care in their handling, storage and use.



The slightest flaw in threading is inescapable as the thread comparator projects a sucker rod pin thread, many times magnified, against a standard pattern to enable thorough inspection of thread details.

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View of the IMPROVED INSERT pump barrel, showing how super-hard wearing surfaces for long life are combined with ductile core for high tensile strength.

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Production Data Study of *Underground Gas Reservoir*

By LEONARD C. DICKEY
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A REVIEW of data required to forecast the probable behavior of a depleted field when utilized as a seasonal storage reservoir for trunkline surplus and to provide a withdrawal bank for peak winter demands. Where old fields lack production data, the author suggests use of data from neighboring and still producing fields.

SEASONAL demands which characterize the natural gas industry make the storage of this fuel in depleted reservoirs a desirable and economic factor, so recognized by the industry for more than 30 years. The present system of natural gas trunk lines is inadequate to meet the peak winter demand of the industrial areas in the Eastern U. S. and engineers recognize the impracticability of building pipe lines of sufficient size to handle maximum winter demand which, in some instances, has been estimated to be six times that of the summer months. By building lines to handle a load between the maximum and minimum requirements, it is possible by the use of underground storage to store excess gas during periods of low demand and draw on it during peak demand periods.

Unfortunately for the industry, very inadequate records seem to have been kept in connection with natural gas fields which are now depleted and which may be used as possible reservoirs. In many instances physical data such as average sand thickness, average porosity and actual areal extent of a pool are not available either because such data were not compiled originally or properly maintained later.

Greenwood Reservoir

The Greenwood natural gas storage reservoir in Steuben County, New York, and which is now being utilized by the Home Gas Company, is a case in point and a study of the production data is presented in this article in the belief that this method may serve as a guide in determining fairly early in the life of a gas field whether it is feasible to plan on using the field for gas storage when it reaches depletion stage, and to give some idea as to the pressure range necessary in its successful operation.

Natural gas was first successfully stored in natural underground reservoirs in 1915 in Welland County, Canada. Since then the use of this type of storage has increased to such an extent that it is now a major operational phase of the natural gas industry. There are more than 70 storage projects in the U. S., approximately 50 being in the Appalachian region. Underground gas storage is ideal provided it is located close to a consuming area and has sufficient volume and deliverability for all emergencies. If the storage pool is available to the pipe line at a point from one-half to three-fourths of the distance to the consuming area, natural gas can be transported from the extreme end of the line in the summer and stored in the natural reservoir for winter use. In addition to stabilizing supply and demand, underground storage absorbs excess gas supplies and maintains the operation of stripper wells, many of which doubtless would be abandoned if shut in during the summer months.

Many important factors must be considered in determining a suitable underground reservoir for natural gas storage including: (a) proper location of the prospective reservoir in relation to gas distribution needs; (b) adequate structural closure of the reservoir; (c) sufficient volumetric capacity of the structure to warrant capital investment; (d) complete lease coverage of the prospective reservoir; (e) sufficient permeability of the reservoir sand to enable injection and withdrawals at high rates over extended periods; (f) production history of the field should be available; (g) data must be obtained on annual production and reservoir pressures, condition of the original wells, open flow tests, daily delivery rates and a sand reasonably free of liquids. In order to obtain these data engineers should make a close study of the field from well and production records. As previously indicated, these are sometimes unavailable and therefore engineers studying the possible advantages of natural underground reservoirs must rely upon production data as assembled for similar projects.

Pressures Erratic

During the entire life of the Greenwood gas field, both as a primary producer and a storage reservoir, accurate measurements have been made of the volumes of gas produced and the volumes of gas injected and withdrawn from storage. Wellhead pressure measurements were taken at various intervals. A review of these data indicates

that pressures have not behaved as is customary in ordinary gas fields but have been erratic.

The Greenwood gas field was primarily produced from 1934 to May, 1941, when it was shut in until July, 1942. After that it was used as a storage project and so remains at the present time. The Oriskany sandstone is the reservoir formation, but its physical characteristics never have been actually determined due to difficulty of securing adequate core samples of the sand. Without cores the laboratory determination of the average porosity and permeability of the gas sand could not be conducted nor could the percent of connate water in the sandstone be determined. Average thickness of the Oriskany sandstone has not been determined, although Hartnagel and Newland[1] estimate a thickness of 14 feet in the Greenwood pool. Porosity, as indicated in the nearby Tyrone field, was reported between 9 and 11 percent.

Analysis of Original Gas

Originally the field contained natural gas, edge or bottom water and interstitial water but no analyses of these have been made. In order to make the necessary calculations it was incumbent to assume an analysis of the original gas. Results were attained by the analysis of gas from a nearby field which was assumed to be similar in character to that at Greenwood. This analysis is tabulated in Table 2. Calculations as to reservoir volume after May, 1941, are based on the injected gas only. Wellhead pressures and volume of gas produced and injected for the period from November, 1934, to September, 1947, were obtained from Home Gas Company.

All volumes of gas withdrawn or injected into the formation were metered. The wellhead pressure measurements were taken with standard test pressure gauges frequently checked for accuracy, and values obtained were used in the determination of the original volume of gas in the reservoir and subsequent reservoir volume for the period from November, 1934, to August, 1947.

Production from the reservoir from November, 1934, to March, 1939, was at a rather slow rate and the pressure declined with production in accordance with Boyle's Law (taking compressibility of the gas into consideration). During 1939 the pressure decline was less than normally could be expected and this indicated that pressure was being maintained to some degree from a source outside the field proper. This condition has been attributed to: (a) seepage of gas into the Greenwood reservoir from a nearby source where pressures were higher than at Greenwood; (b) gas expansion in another field connected by a salt water saturated formation to the Greenwood reservoir; and, (c) edge or bottom-hole water encroachment. As of August, 1947, the field pressure had declined to approximately 60 percent of the initial pressure although 92 percent of the calculated original gas in place had been produced.

The theory that the pressure in the Greenwood reservoir is being maintained by a hydrostatic head is supported by the fact that the original reservoir pressure of the field was 2139 pounds per square inch, while the pressure exerted by a column of water equivalent to the depth of the producing sand at 4700 feet is also 2139 pounds per square inch. The area is known to be faulted, which would make water encroachment into the sand quite likely, and it is significant that all but one well in the field have been invaded by salt water and abandoned. In the Greenwood field the pressure at the gas-water interface is approximately 2100 pounds per square inch.

Determining Original Gas

There are two basic methods which can be used in determining original gas present in a reservoir: the porosity-area method and the pressure-volume method. If possible, both methods should be used. The first requires accurate information as to areal extent of the field, thickness of gas sand, porosity, percentage of connate water in the sand, average reservoir temperature, initial reservoir temperature. The second method is based on the relationship between reservoir pressure decline and volume of gas produced. This requires information on initial reservoir pressure, reservoir temperature, gas analysis, and the reservoir pressure after a definite quantity of gas has been produced. Unfortunately, most of these factors were overlooked or records improperly prepared in the early development of the gas industry and therefore are not readily available to the engineer who is engaged in assembling data for a natural gas storage project. Lack of information made it impossible to use the

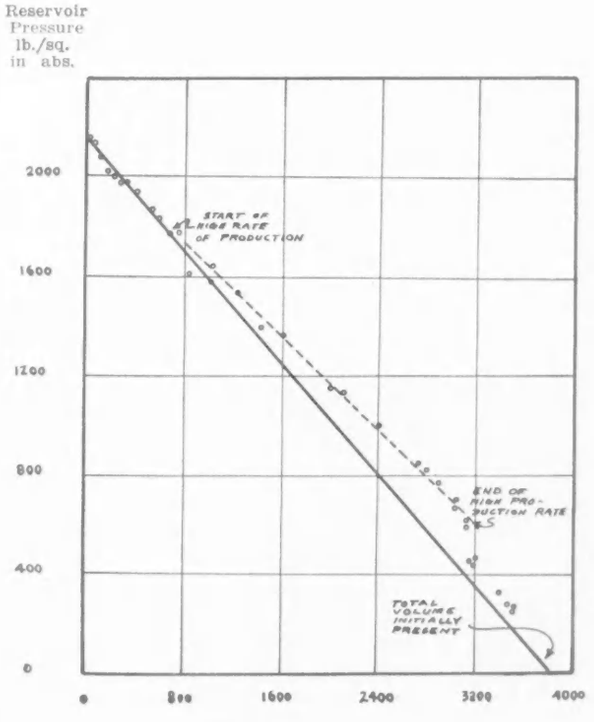

FIGURE 1. Remaining reservoir pressure vs. cumulative production.

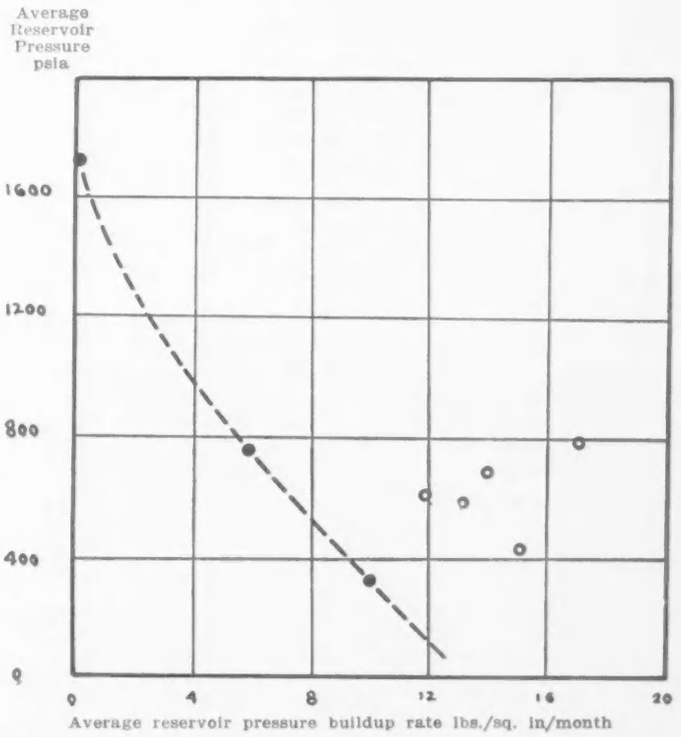

FIGURE 2. Pressure buildup rate (shutin) vs. average reservoir pressure.

pressure-area method in the Greenwood field as no exact records were available concerning porosity, areal extent and sand thickness.

Based on standard conditions for volume measurements taken as 14.74 pounds per square inch and 60° F, and with observed temperature of 122° F. at Greenwood, determination of the original reservoir volume and the original volume of standard cubic feet of gas in place are based on production data from November, 1934, to March, 1939.

Volume Determination

The original volume of gas in place as determined graphically, (Figure 1) is 3800×10^6 standard cubic feet. The original reservoir volume (void space filled with gas) is 24.7×10^6 cubic feet. The determination of the original gas present consisted of plotting the cumulative production in cubic feet against the remaining reservoir pressure, pounds per square inch absolute, for the period from 1934 to 1941. The determination was based on this period because the calculated reservoir volume remained constant during this time. The original volume of gas present was then taken as the volume of gas that would have to be withdrawn to reduce the reservoir pressure to one atmosphere. The volumes obtained by calculation are 3300×10^6 standard cubic feet, and 20.9×10^6 cubic feet, respectively. It is believed that the graphical solution is the more reliable of the two because the assumed gas analysis does not enter into the determination. The difference between the two is probably due to error in the assumed original gas analysis.

Table 3 contains the tabulated calculations from the original reservoir volume and subsequent reservoir volumes based on the general gas law. Columns 1, 2, 3 and 4 are taken from the records as Home Gas Company. Column 5 is the compressibility of the gas based on the law of corresponding states. Column 7, the standard cubic feet of gas in one cubic foot of pore space in the reservoir, is obtained as follows:

From the general gas law

$$PV = ZNRT$$

The volume, V_s, of one pound mole of gas at standard conditions is:

$$V_s = \frac{10.71 \times 1 \times 1 \times 520}{14.73} = 378.08 \text{ cu. ft.}$$

The volume of one pound mole of gas under reservoir conditions where the reservoir conditions are Temperature = 582° Rankine, Compressibility factor = Z_R Pressure = P_R is:

$$V_R = \frac{10.71 \times Z_R \times 1 \times 582}{P_R} 6230 \times \frac{Z_R}{P_R}$$

The number of standard cubic feet of gas in one cubic foot of pore space is:

$$378.08 \div \left[6230 \times \frac{Z_R}{P_R} \right]$$

Values for the gas released, Column 8, are then obtained by subtracting the values of Column 7 from the original value, 158.0. Column 9, values for the total cubic feet of pore space, is obtained by dividing the total gas produced, Column 2, by the total gas released per cubic foot of pore space, Column 8. Column 10, the calculated initial volume of gas present in the reservoir in standard cubic feet, is the product of Column 9 and the initial volume of gas in one cubic foot of pore space, the first figure in Column 7.

Columns 11 and 12 have been added to Table 3 because it is felt that the initial volume of gas present as determined by the graphical solution was the more accurate. Column 11 is the remaining volume of gas in the reservoir assuming that the original volume was 3800×10^6 standard cubic feet. Column 12 is the calculated reservoir volume based on the volumes of column 11. It is determined as follows:

$$\frac{P_S V_S}{T_S Z_S} = \frac{P_R V_R}{T_R Z_R}$$

$$V_R = \frac{P_S V_S T_R Z_R}{P_R T_S Z_S}$$

$$V_R = \frac{14.7 V_S 582 Z_R}{P_R 520 1} = (16.5) \frac{V_S Z_R}{P_R}$$

S = Standard Conditions
R = Reservoir Conditions
$P_S = 14.73$ #/sq. in. abs.
$T_S = 520$ R.
$T_R = 582$ R. $Z_S = 1$

Table 4, calculated reservoir volumes for the period May, 1941, to August 27, 1947, is the tabulated calculations in determining the reservoir volume and the change in volume for this period. The data for the calculations were obtained from production records of Home Gas Company. It is assumed in these, as in previous calculations, that the bottom-hole pressure as calculated from the measured wellhead pressure is equal to the reservoir pressure regardless of the length of time the well was shut in prior to the measurement.

Columns 1, 2, 3 and 4 are basic data. Column 5 is the cumulative change in the volume of gas in the reservoir. Column 6, the total volume of gas in the reservoir, is based on the original determination of 3800×10^6 standard cubic feet of gas initially present in the reservoir. Column 7 is the compressibility factor of the injected gas. Column 8, the calculated reservoir volume necessary to contain the total reserves of Column 7, is obtained as follows:

$$\frac{P_S V_S}{T_S Z_S} = \frac{P_R V_R}{T_R Z_R}$$

$$V_R = \frac{P_S V_S T_R Z_R}{P_R T_S Z_S} = (16.5) \frac{V_S Z_R}{P_R}$$

S = Standard Conditions
R = Reservoir Conditions

Column 9 is the calculated change in the reservoir volume between successive calculations. From the values in this column it would appear that the reservoir volume is increased at various times because of the injection of gas; however, it is felt that this is not the case. This apparent increase in the reservoir volume is caused by errors in the pressure measurement and the fact that the pressure measurements were made before the bottom-hole pressure and the reservoir pressure were equalized. In these cases the bottom-hole pressure is not representative of the reservoir pressure as has been assumed.

After May, 1941, the field was shut in several times for periods ranging from

TABLE 1

Date	Farm	Drilling Company	Elevation	Depth to Orisk.	Total Depth	Initial Pressure Well H.	Initial Production
1932	Warriner	Wittmer	2079	4550	4555	....	500 MCF/day
....	L. Webber	Wittmer	1791	4256	4266	....	Gas
1934	State Land No. 1	Empire G. & F.	2222	4705	....	1930	Gas
....	O'Harrigan	Wittmer	2284	4728	....	....	Gas
....	Coston No. 2	Belmont	2299	4737	4738	....	Gas
....	Coston No. 1	Belmont	2016	4539	4547	....	Salt Sater
....	William Ackley	Wittmer	1980	4553	4556	....	Gas
....	M. Ackley	Hanley & Bird	2044	4499	4506	....	Salt Water
1937	L. D. Clark	.....	2264	4758	....	1760	15,000 M CF/day
1937	A. Coston	.....	1712	4179	....	....	Salt Water
1938	Caffery	.....	2072	4586	4593	....	Salt Water
1939	Ray Schribner	G. L. Cabot	....	4173	....	....	Salt Water
1939	Larry Hyland	G. L. Cabot	....	4745	....	....	Salt Water
1939	Lewis Weber	G. L. Cabot	....	4353	....	....	Dry
1939	Wm. Ackley	Belmont Quad.	....	4721	....	....	Salt Water
1940	Mary Barger	Hanley & Bird	1871	4560	....	....	Salt Water
1940	State Land No. 2	Empire G. & F.	2349	4831	....	405	5,500 MCF/day
1940	Stanley Murray	Hanley & Bird	2313	4870	....	....	Salt Water
1940	Charles Fisher	Hanley & Bird	2228	4804	....	....	Salt Water
1942	William Pease	N.Y. State Nat. Gas	2212	4840	4844	....	Salt Water
1943	Mary Rogers	Hanley & Bird	2329	4888	4891	....	Salt Water
1944	Warriner No. 2	Appalachian Dev.	1896	4366	4372	....	Salt Water
1944	S. Murray No. 2	Belmont Quad.	2314	4859	4863	....	Gas, Salt Water
1944	William Hyland	Appalachian Dev.	2348	4820	4822	....	Salt Water

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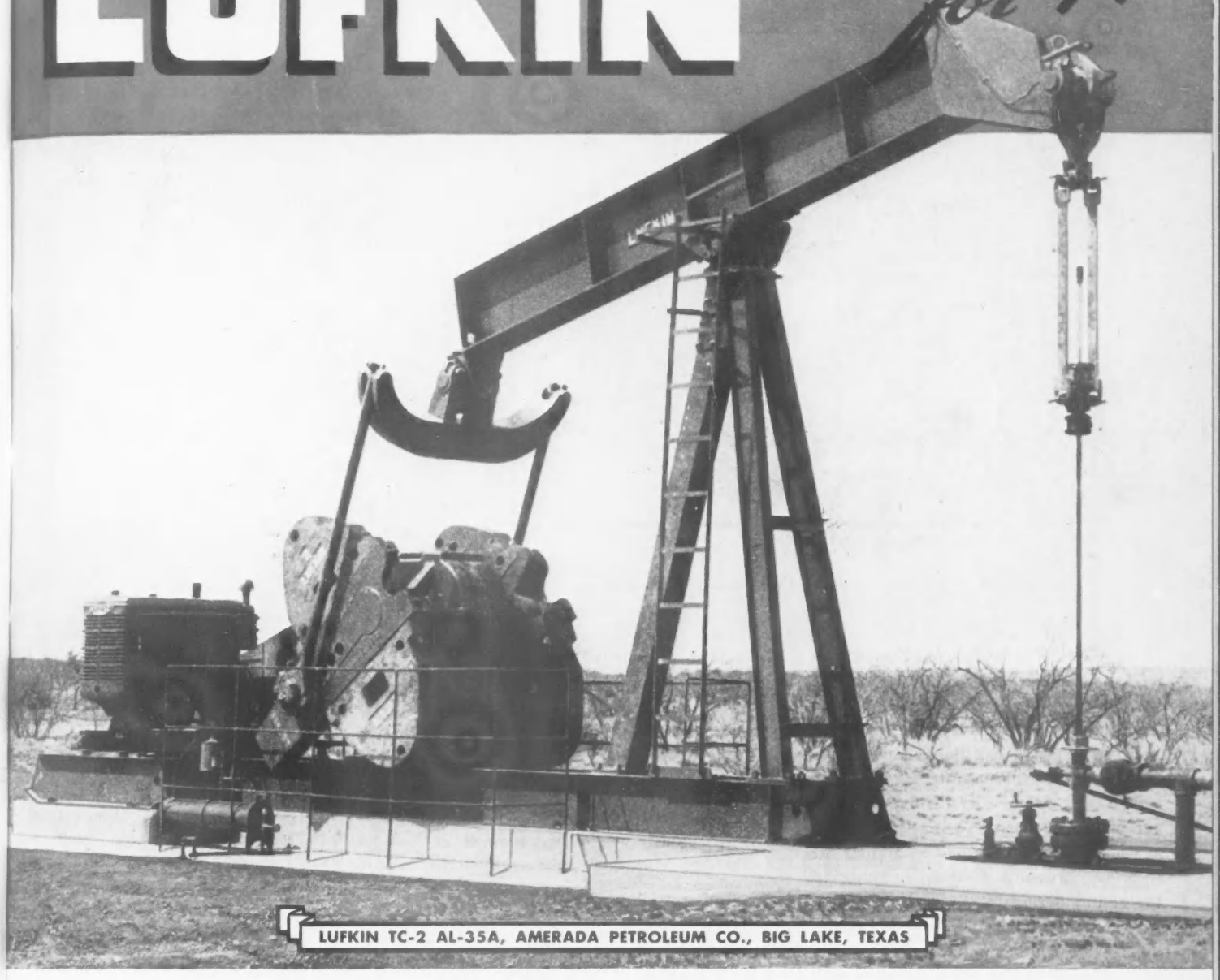
the line for 49



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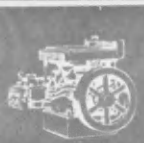

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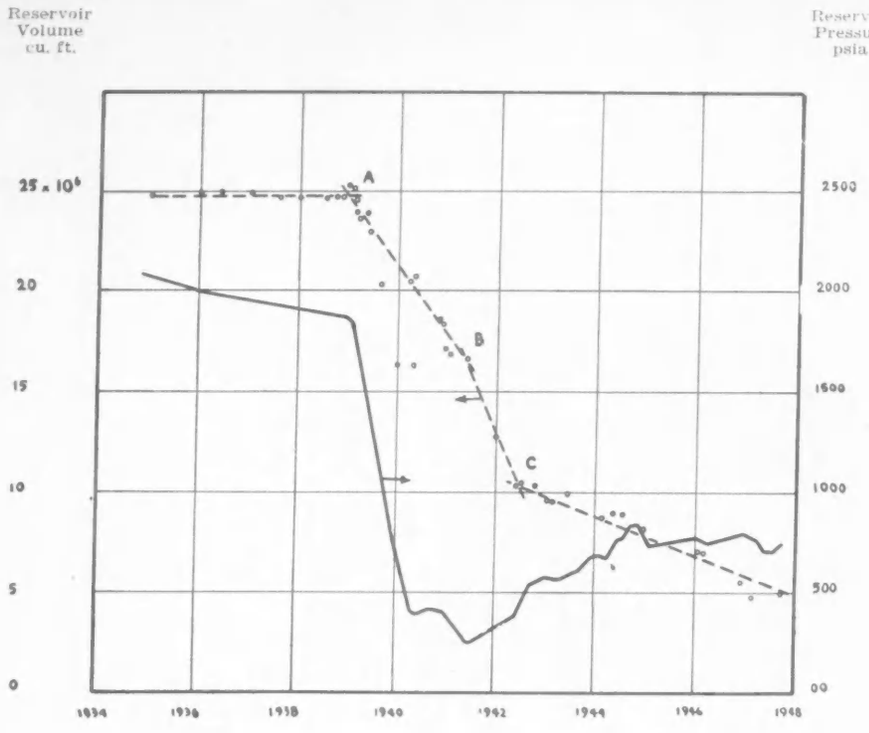


FIGURE 3. Reservoir volume and reservoir pressure vs. months.

16 months to a few days. During the shutin periods it was noticed that the wellhead pressure increased although no gas was being injected into the reservoir. Figure 2 is the plot of the average reservoir pressure buildup rate (pounds per square inch per month) against the average reservoir pressure (psia). The average pressure was obtained by adding the reservoir pressure at the beginning of the shutin period to the reservoir pressure at the end of said period and dividing by two. Only two of these points are considered accurate since it was necessary to shut in the reservoir for a sufficient period to permit the reservoir pressure to become stabilized before taking a pressure measurement.

Buildup Rates

The other buildup rates based upon a shutin period of from a few days to approximately three months are also plotted on Figure 2. The irregularity of these determinations indicates that a rather long period of stabilization is necessary in the Greenwood pool. It is realized that with only two points to determine the shape of the buildup rate, the plot is not very satisfactory; however calculations are consistent with the formula for flow of fluids through porous media. In addition to the buildup rates determined during the shutin periods, the point of no encroachment, as determined in Table 3, is included on the pressure plot.

On extrapolating the two points in a straight line an average reservoir pressure of 1400 pounds per square inch is obtained for the point of no encroachment. A maximum pressure buildup rate of approximately 13 pounds per square inch per month would be obtained at an average reservoir pressure of one atmosphere.

The average reservoir pressure of 1400 pounds per square inch is within 18 percent of the value obtained in Figure 3 for the minimum pressure at which there is no encroachment. This difference could result from error in the data or could be explained by a change in the character of the reservoir sand into which the salt water is encroaching.

Figure 3 is a plot of the calculated reservoir volumes and the calculated reservoir pressure against time. The values for this figure were taken from Tables 3 and 4. From the volume line in Figure 3 it is apparent that the edge or bottom water began to enter the reservoir early in 1939, at which time the reservoir pressure was approximately 1700 psia. This indicates that the pressure differential necessary for the encroachment is approximately 450 pounds per square inch. It also indicates that the reservoir pressure would have to be maintained at approximately 1700 psia, or greater, to prevent further encroachment. This would require a wellhead injection pressure of approximately 1530 psia.

The volume points between A and B on the graph fall erratically, because the pressure is being reduced at a high rate as the gas is produced at a high rate and the measured wellhead pressures are not at all representative of the reservoir pressure. The volume line for this section is therefore based on the early values and those obtained after the rate of production has been decreased. The slope of this section is—3.0×10^6 cubic feet per year. The average pressure for this section can be considered approximately 720 pounds per square inch.

For the section of the graph from B to C, the slope is approximately —6.45×10^6 cubic feet per year. The average reservoir pressure for this period is 343 psia. During this period the field was shut in.

For the section of the graph from C to August, 1947, the values of the reservoir volume follow a general trend, although they do not fall exactly on a line. The slope of the line is —1.0×10^6 cubic feet per year. The average reservoir pressure for this section is approximately 752 psia.

Original Volume

From this study of the production data it was possible to determine the original volume of the Greenwood gas field to be 3800×10^6 standard cubic feet of gas (14.73 pounds per square inch and 60°F). The original reservoir volume was determined to be 24.7×10^6 cubic feet. This volume has been decreased by salt water encroachment until, as of August 1947, the volume was approximately 5×10^6 cubic feet.

The salt water encroachment is a function of the pressure differential and

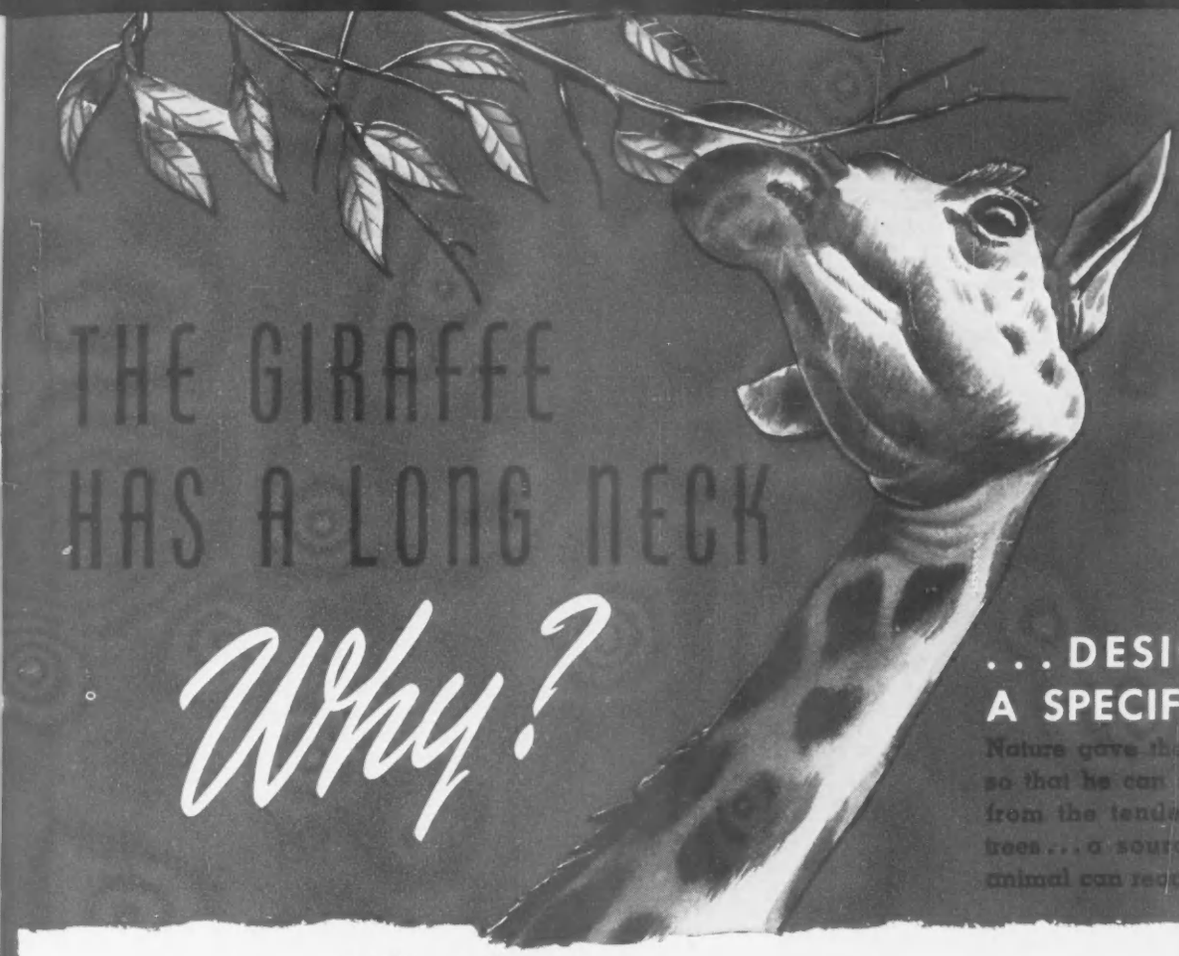
TABLE 2

Original Gas (Assumed)

Composition	Volume Percent
Methane	88.8
Ethane	10.0
Nitrogen	0.5
Specific Gravity	.59
Thermal Value	1071 Btu (Dry)
Thermal Value	1050 Btu (Saturated)
Critical Pressure	671 Psia.
Critical Temperature	362 Rankine
Average Molecular Weight	17.39

Injected Gas

Composition	Volume Percent
Methane	93.54
Ethane	4.13
Propane	1.14
Butane	.28
Specific Gravity	.592
Thermal Value	1040 Btu
Critical Pressure	668 Psia.
Critical Temperature	354.4 Rankine
Average Molecular Weight	16.89



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time. Although it was not demonstrated by any calculation or data in this study, encroachment is obviously a function of the character of the sand and also of the nature of the encroachment fluid.

Assuming the water encroachment is a reversible process in that the encroaching water will recede if the pressure differential is reversed, then it would be necessary to build the pressure of the gas in storage up to approximately 2600 pounds per square inch before the withdrawal will be noticeable.

By analyzing the production data in the manner presented in this paper, it is possible to determine early in the life of a field whether the pool is subject to water encroachment and to determine qualitatively the pressure range at which the pool will have to be operated to maintain the initial reservoir volume and prevent the encroachment water from decreasing the reservoir volume.

This method as presented can be used in cases where reservoir data such as sand thickness, porosity, permeability and areal extent are not available or of doubtful accuracy. When such information is available it would be possible by pressure-area calculations to check the results obtained by this method.

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[1] Hartnagel, C. A., Newland, D. H., AIMME Transactions, Petroleum Development and Technology, Production Division, 1940.

TABLE 3

Calculated Reservoir Volumes for the Period from November, 1934, to May, 1941.

1	2	3	4	5	6	7	8	9	10	11	12
Date	Volume of Gas Produced	Well Head Pressure Lb./Sq. In. Ga.	Reservoir Pressure Psia.	Compressibility Factor Z	P / Z	Standrad Cu. Ft. of Gas in One Cu. Ft. of Pore Space	Volume of Gas Released From One Cu. Ft. of Pore Space in the Reservoir Std. Cu. Ft.	Calculated Volume of Pore Space Necessary to Produce Total Gas Production	Calculated Initial Volume of Gas Present in Reservoir in Std. Cu. Ft.	Std. Cu. Ft. of Gas Remaining in Reservoir Based on 3800x10⁶ Cu. Ft. Original Vol.	Calculated Reservoir Volume Based on Remaining Vol. in Col. 11
November, 1934	0x10⁶	1930	2139	.823	2600	158.0	0	.....	.....	3800x10⁶	24.20x10⁶
January, 1935	15	1910	2117	.824	2583	156.9	1.1	13.60x10⁶	2150x10⁶	3785x10⁶	24.30x10⁶
June, 1935	60	1860	2062	.825	2505	152.2	5.8	10.35	1635	3740	24.65
January, 1936	120	1820	2018	.827	2440	148.2	9.8	12.25	1933	3680	24.90
June, 1936	160	1800	1996	.827	2413	146.7	11.3	14.17	2240	3640	24.90
January, 1937	220	1780	1974	.829	2385	145.0	13.0	16.90	2670	3580	24.83
June, 1937	280	1780	1974	.829	2385	145.0	13.0	21.50	3395	3520	24.40
January, 1938	350	1735	1924	.832	2313	140.8	17.2	20.30	3230	3450	24.60
June, 1938	340	1735	1924	.832	2313	140.8	17.2	19.75	3120	3460	24.65
November, 1938	360	1720	1908	.833	2292	139.2	18.8	19.15	3030	3440	24.80
December, 1938	400	1714	1901	.833	2282	138.9	19.1	20.94	3310	3400	24.55
January, 1939	490	1670	1853	.835	2222	134.9	23.1	21.20	3320	3310	24.60
January, 1939	560	1620	1798	.837	2147	130.7	27.3	20.50	3240	3240	24.90
February, 1939	800	1490	1655	.845	1958	118.8	39.2	20.40	3225	3000	25.30
Feb.-March, 1939	900	1450	1611	.847	1905	115.8	42.2	21.30	3360	2900	25.10
March, 1939	1000	1430	1589	.848	1883	114.4	43.6	22.90	3620	2860	25.20
March-April, 1939	1200	1350	1501	.852	1765	107.0	51.0	23.53	3710	2600	24.40
April, 1939	1400	1250	1391	.862	1614	98.2	59.8	23.50	3710	2400	24.55
May, 1939	1600	1190	1325	.865	1532	93.1	64.0	24.65	3900	2200	23.65
June, 1939	1720	1145	1276	.870	1468	89.2	68.8	25.00	3950	2080	23.40
July, 1939	1900	1035	1155	.880	1313	79.8	78.2	24.30	3840	1900	23.80
August, 1939	2100	980	1094	.884	1240	75.4	82.6	25.40	4020	1700	22.60
October, 1939	2400	880	984	.892	1116	70.5	87.5	27.40	4330	1400	20.70
January, 1940	2890	700	786	.913	863	52.4	105.6	27.30	4320	910	17.40
March, 1940	3150	540	610	.932	654	39.7	118.3	26.60	4210	650	16.40
June, 1940	3190	400	456	.948	482	29.3	128.7	24.80	3920	610	20.90
July, 1940	3200	380	434	.950	457	27.8	130.2	24.60	3890	600	21.70
August, 1940	3200	385	441	.950	457	27.8	130.2	24.60	3890	600	21.70
October, 1940	3200	400	456	.948	482	29.3	128.7	24.90	3930	600	20.50
November, 1940	3240	380	434	.950	457	27.8	130.2	24.90	3930	560	20.20
December, 1940	3320	370	422	.952	443	26.9	131.1	25.30	4000	480	17.87
January, 1941	3370	340	389	.955	407	24.7	133.3	25.30	4000	430	17.40
April, 1941	3370	240	258	.970	266	16.2	141.8	23.80	3760	430	26.60
May, 1941	3520	210	247	.970	255	15.5	142.5	24.70	3900	280	18.10

TABLE 4

Calculated Reservoir Volumes for the Period from May, 1941, to August 27, 1947

1	2	3	4	5	6	7	8	9
DATE	Well Head Pressure Psia.	Bottom Hole Pressure Psia.	Volume of Gas Injected or Withdrawn MM Std. Cu. Ft.	Cumulative Change in Volume of Gas in the Reservoir MM Std. Cu. Ft.	Total Volume of Gas in the Reservoir MM Std. Cu. Ft.*	Compressibility Factor Z	Calculated Necessary Reservoir Volume to Contain Reserves MM Cu. Ft.	Calculated Change in Reservoir Volume MM Cu. Ft.
May, 1941	210	247	.....	.....	280.00	.974	18.20	.....
Januray, 1942	305	351	.....	.....	280.00	.964	12.70	— 5.50
July, 1942	370	423	.....	.....	280.00	.960	10.49	— 2.21
July, 1942	380	434	9.95	9.95	289.95	.960	10.49	0.00
October, 1942	530	599	116.56	126.51	406.51	.954	10.57	0.08
February, 1943	527	596	—30.71	95.80	375.80	.940	9.75	— 0.82
March, 1943	515	583	—16.65	79.15	359.15	.943	9.56	— 0.19
October, 1943	680	765	144.62	223.77	503.77	.924	10.00	0.44
April, 1944	615	693	—118.48	105.29	385.29	.932	8.54	— 1.46
August, 1944	720	808	112.45	217.74	497.74	.920	9.32	0.78
October, 1944	780	874	36.92	254.66	534.66	.914	9.22	— 0.10
February, 1945	661	744	—135.53	119.13	399.13	.926	8.22	— 1.00
February, 1946	680	765	— 44.65	74.48	354.48	.924	7.06	— 1.16
March, 1946	675	757	— 9.00	65.48	345.48	.923	6.92	— 0.14
January, 1947	680	764	— 79.81	— 14.33	265.67	.924	5.08	— 1.84
March, 1947	610	686	— 70.33	— 84.66	195.34	.933	4.38	— 0.70
August, 1947	755	847	61.91	— 22.75	257.25	.916	4.58	0.20

* Assuming 3800 x 10⁶ standard cubic feet of gas originally present in the reservoir.

...LOW IN COST • TOPS IN PERFORMANCE • PERFORMS THREE PRODUCTION JOBS

Larkin FORGED STEEL TUBING HEADS

When this well stops flowing, the operator can keep right on producing through this Type "R" Larkin Tubing Head for the life of the well. It can be adapted to gas-lifting or pumping wells. It will serve dependably from completion to depletion. Low in initial cost and upkeep, Larkin Forged Steel Tubing Heads offer more for your money than any other low cost tubing head. And for that reason, more and more operators are turning daily to Larkin Tubing Heads. Its valuable combination of features can be found in no other head in the same price field. The all-forged steel Larkin Tubing Head shown here . . . 4500 lbs. test . . . can be bought through your supply store.

LARKIN

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LARKIN PACKER COMPANY, INC.
ST. LOUIS, MO.

Problems of Water Injection in Wells and Corrective Methods

Part 2 Chemical Problems in Salt Water Injection

By L. C. CASE, Gulf Oil Corporation

LARGE volumes of salt brine were not produced from oil fields discovered prior to 1900. It was, therefore, a natural result that water injection in wells was first used as a means of driving more oil from sub-surface oil sands, rather than as a method of salt brine disposal. Water flooding of oil sands began to show promise in the Bradford, Pennsylvania field soon after 1900. Salt brine disposal by the injection method was practiced to some extent in Oklahoma as early as 1925. This may have been the first pumpage of brine to wells, solely for the purpose of nuisance removal. The problem of disposal of large quantities of oil field brine became rather serious in western Kansas oil fields soon after 1930. Probably, initial success of the well injection method in Kansas led to early adoption elsewhere. In any event, salt brine disposal by well injection had its greatest expansion in the decade following 1930. In contrast, water injection for flooding purposes, although discovered somewhat earlier, had greatest growth a few years later, as a result of increasing demand for crude oil and the development of the science of oil reservoir engineering which led the way to more successful waterflooding practice.

The chemical problems encountered during the injection of waste oil field brine into disposal wells do not differ greatly from those in water flooding. Many of the attendant physical factors are different and, in general, these modifications serve to minimize the difficulties of salt water injection into wells. In salt water disposal the object is primarily that of injecting the waste brine to the underground so that it will not pollute soil or surface water sources. Usually, it becomes convenient to convert a marginal oil well, or one which is situated at the extreme edge of an oil field, into a salt water disposal well. Injection of large volumes of water into or below the oil formation of a well thus located usually is beneficial to oil production rather than otherwise. If such a well is not available, it becomes necessary to drill a well solely for salt water disposal purposes. The ultimate goal in the drilling of all salt water disposal wells is to find a formation of sufficient injection capacity so that the well will operate trouble-free during the life of the nearby oil field. Therefore, a salt water disposal well is drilled below the greatest depth at which any fresh water can occur and completed in the highest formation which is shown by actual injection tests to have the desired input capacity. Usually, existing water analyses and geological information on subsurface formations serve rather well in the location and completion of disposal wells. However, only the actual injection test is final and acceptable proof of adequacy.

TABLE 7
Underground Disposal of Unfiltered, Waste Brine. Individual Well Data

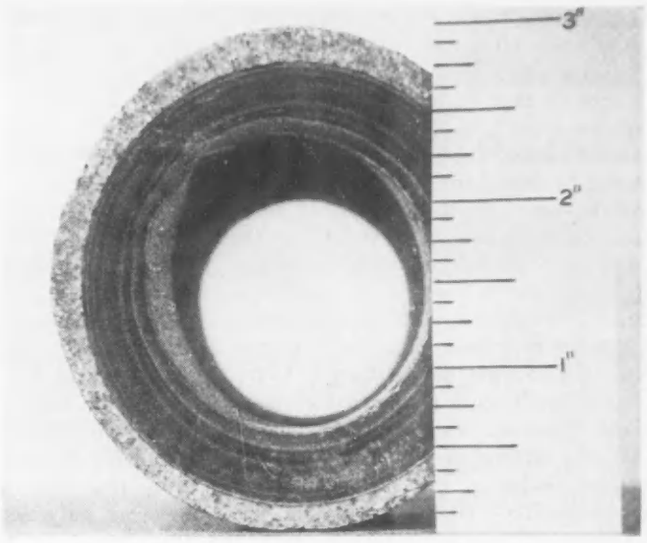
Formation, State	Waste Brine Input, Barrels		Type of System	Input Pressure, psi.	Well Clean-out Methods, Frequency
	Daily	Cumulative			
Arbuckle lime, Kansas	8,500	27,750,000	Semi-closed	Vac.	2 acid and 3 tool jobs—11 years.
Dakota sand, Kansas	840	3,140,000	Semi-closed	105	2 acid and 4 tool jobs*—11 years.
Bartlesville sand, Oklahoma	330	994,000	Semi-closed	Vac.	1 tool job—10½ years.
Gilcrease sand, Oklahoma	400	120,000	Semi-closed	Vac.	None—13 months.
Cypress sand, Illinois	300	394,000	Semi-closed	Vac.	None—2½ years.
Devonian lime, Illinois	3,780	4,020,000	Semi-closed	Vac.	7 acid jobs—5 years.
Tar Springs sand, Illinois	2,700	4,115,000	Semi-closed	350	6 acid jobs—6 years.
Dundee lime, Michigan	3,100	9,285,000	Semi-closed	Vac.	8 acid jobs—8 years.

* Including drilling deeper twice.

TABLE 8
Chemical Nature of Waste Brines

FIELD	Western Kansas	Burbank, Oklahoma	Cheyarha, Oklahoma	St. James, Illinois	Centralia, Illinois	Freeman Michigan
Formation	Arbuckle Lime	Bartlesville Sand	Gilcrease Sand	Cypress Sand	Benoist Sand	Dundee Lime
Na + K	6,388	58,450	50,644	30,156	33,320	68,600
Ca	1,391	15,960	11,170	1,625	3,610	38,300
mgm./1. Mg	396	2,344	1,608	902	1,308	7,060
SO_4	1,792	nil*	120	390	trace	155
Cl	14,818	125,200	102,380	51,520	61,600	194,400
HCO_3	701	24	113	392	24	13
Total Sclids	27,508	201,978	166,035	84,922	99,862	308,528
Sp. Gr. @ 60° F.	1.020	1.141	1.121	1.062	1.067	1.212
H_2S	237 mgm./1.	nil	nil	0-20 mgm./1.	nil	trace
Fe	trace	20-50 mgm./1.	10-25 mgm./1.	trace	8-27 mgm./1.	trace
pH	6.4-6.8	6.5	6.6	5.7-6.7	6.4	5.8

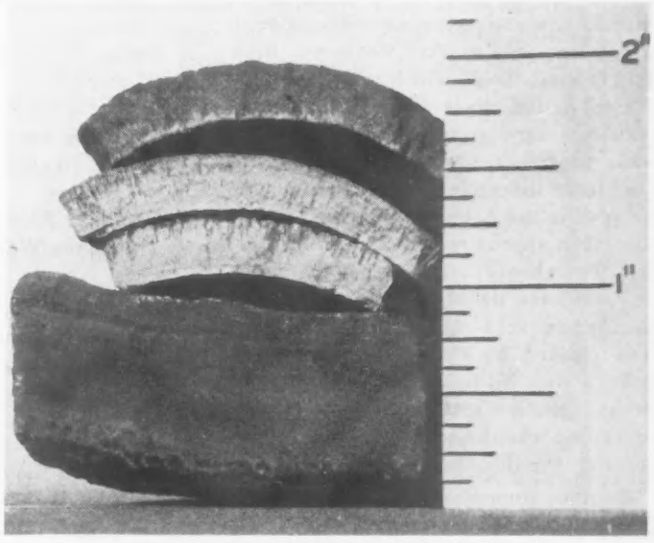
* Contains trace to 175 mgm./1. Ba.



UPPER LEFT: Hard scale formed in waste brine line where incompatible waters were mingled. The deposit is rather pure strontium sulfate.

UPPER RIGHT: Hard scale in waste brine gathering line. Outermost ring is cement lining. Scale consists of calcium carbonate, calcium sulfate, iron sulfide, dirt and oil.

LOWER RIGHT: Lead line deposit, New Mexico. This is exceptionally pure calcium carbonate. Bottom piece contains appreciable oil.



In water-flooding practice it is desirable to inject flood water at a slow, even rate so that the "water front" will not bypass the oil in the formation. On the other hand, any channeling effect of salt water disposal is more desirable than otherwise. Thus, a salt water disposal well may be shot with heavy charges of nitroglycerin or, if it is sufficiently calcareous or dolomitic in nature, it may have input capactiy increased enormously by charges of hydrochloric acid, sometimes of several thousand gallons. Obviously, large crevices should take greater volumes of waste brine which is not entirely free of suspended matter.

The chemical relationships, as well as physical factors, are somewhat more favorable to salt water injection. Ordinarily, salt water from one formation will be compatible with that in another. Rare exceptions have already been illustrated where admixture of brines containing barium or strontium with those having sulfates would cause insoluble deposits. It has also been shown previously that fresh water sometimes has a "plugging effect" on sand permeability which is due to swelling of interstitial clay particles. Salt water does not exhibit this tendency.

Generalized Data on Waste Brine Injection

In view of the above brief discussion, it would seem that practical rules for successful salt water injection are rather few in number and fundamental in principle. If the waste brine is compatible with that of the disposal formation, then it should be necessary merely to remove all oil and prevent precipitation of dissolved iron and calcium carbonate. A review of the data, which cover several years of operating disposal wells, now indicates that proper selection of disposal formations and the use of semi-closed or closed systems make brine coagulation and filtration unnecessary. The cleanout jobs involved a great deal less cost than filter maintenance alone during the period of waste brine injection. The generalized data in Table 7 show that the few rules hold rather well during several years of actual practice. It would be impossible, in a recapitulation of this kind, to make the data either complete or self-explanatory. The data on individual salt water injection wells which are summarized in the table do not describe all the salt water disposal operations of even one oil company. These wells were selected merely as being representative of the waste brine injection oprations of one major oil company in several states. It will be noted that filters are not used at any of these wells. Prior to the accumulation of considerable data on injection well operation, it was believed that waste brines should be filtered before injection into sandstone formations. However men in charge of these operations decided to inject water without filtration, cleaning out the wells and installing filters later if necessary. Later experience has shown that periodic well cleanout is usually more practical than filter maintenance. The data indicate that limestone wells have received about as frequent cleaning as wells completed

in sandstone formations. Although cumulative waste brine to sandstone wells compares favorably in many instances to that of limestone wells, the limestone wells in general have the greater input capacity which is not shown by actual total water injected. It will be noted that all limestone wells take brine under vacuum, while the brine must be pumped under considerable pressure to two of the sandstone wells. The "semi-closed" type of system means, in this discussion, that the open tank or salt water gathering pit is covered by crude oil to prevent unnecessary contact with air. Experience has shown that this method of lessening precipitation of sludge in the system is fairly effective. The method of injecting several hundred gallons of acid is ordinarily much more economical than cleaning out a well with tools. Quite naturally, if a well is plugged with material which responds to acid treatment, then acid is used. Tools which may be necessitated in the event of insoluble material may vary from bailers to boring tools to suit a particular problem. At one time the injection tubing was plugged in the Arbuckle lime well which has taken approximately 28 million barrels. The chemist advised that the material consisted mainly of sulfur and was thus quite acid-insoluble. This tubing was cleaned by the novel method of using a rock bit inside the tubing, while using "reverse circulation" which in turn prevented the loosened material from entering the disposal formation.

Another somewhat remarkable job of disposal well cleaning involved a well that received about 5000 barrels of waste brine daily. A chemist had made some tests on the waste brine and found that each 1000 barrels carried 50 pounds or more of sludge which was mainly oil. The well became plugged and, as predicted by the chemist, failed to respond to acid treatment. Because loss of this well presented very serious difficulties, it was quickly decided to spare no expense in reconditioning. Injection of 10,000 gallons of butane removed the oil sludge accumulation near well bottom. Thereafter, 5000 gallons of 15 percent HCl restored the well to its original input capacity. It should be added that the well was equipped immediately with sludge-removal basin and this trouble has not recurred in ten years of operation.

Petroleum engineers who have worked in the field with salt water disposal projects probably deserve much more credit than other technicians in the development of successful methods. These men evolved accurate methods for measuring injection capacity and called on chemists for advice as needed concerning removal and prevention of plugging deposits. They have done their job so well that it is now rather common practice for major oil companies to place all responsibility of salt water injection for a given area in the hands of one experienced engineer. The chemist is still consulted on occasions of apparently decreasing frequency.

Common Chemical Problems in Salt Water Disposal

At the outset, the chemist was in possession of little information of value. Analyses of waste brines resulted in data similar to that shown in Table 8. It is possible to predict from such analyses that certain brines will tend to deposit calcium carbonate and sulfur when aerated, while others will tend to deposit hydrated oxides of iron. The degree of such precipitation may not be stated from laboratory work because samples are never representative by the time they reach the laboratory. Another difficulty is that the pH of calcium carbonate saturation cannot be calculated for such brines even if samples are taken and tested at the pit. The use of stability calculations is now recognized to be of considerable value as applied to fresh waters. These calculations have been applied to some of the more dilute brines[2] but are generally believed to furnish indications only in such cases.

Many interesting chemical relationships are presented incidental to any general consideration of waste brines. Probably the fact that these relationships are minor and incidental has prevented their full and satisfactory explanation. Most brines are observed to rise in pH value when blown with air. This would be a natural effect of loss of CO_2. The same effect is obtained by heating. In rare cases brines are reported to have lower pH value after heating which, in turn, is adjudged as due to the presence of organic acids.[2,3] Appreciable quantities of bromine and iodine are usually present as well as small amounts of many other elements. It is extremely doubtful if any really complete brine analyses have ever been made. The rather detailed analysis of brine from southeastern Kansas, Table 9, does not include iodine, bromine, or trace amounts of many elements which may be present. It will be noted that the total solids at low red heat are still slightly greater than the total of all determined constituents; therefore some undetermined constituents are indicated. This analysis is shown merely in contrast to the usual partial analyses, ordinarily made in haste and sometimes in large numbers for purposes served no better by more complete and time-consuming work.

Space does not permit illustration of the chemical nature of all types of sludge deposits which are troublesome in brine injection systems. In general, the constitution of these deposits corresponds to the chemical nature of the water being injected and accompanying physical conditions. The few analyses stated in Table 10 illustrate some of the relationships. It will be noted that the deposit from the injection tubing is definitely not acid-soluble, necessitating removal by boring tool. This material is typical of deposits formed in injection tubing handling waste Arbuckle brine. The material from the brine pit is easily disintegrated by acid although it contains a much higher amount of wind-blown inert material. This type of sludge is rather commonly found on

■ CONTINUED ON PAGE 152

TABLE 9
Analysis of Arbuckle Brine, Southeastern Kansas

mgm./l.		Hypothetical Combinations	
NH_4	nil	$Fe(HCO_3)_2$	1
Li	0.6	$Ca(HCO_3)_2$	421
Na	15,541	$CaSiO_3$	17
K	290	$CaSO_4$	50
Ca	1,946	$CaCl_2$	5,047
Mg	716	$MgCl_2$	2,805
Ba	nil	NaCl	39,497
Sr	nil	KCl	553
Fe	0.3	LiCl	4
SiO_3	11		
SO_4	35		
Cl	29,538		
HCO_3	317		
CO_3	nil		
NO_3	nil		
Total	48,394.9		48,395
Sp. Gr. @ 60° F.	1.038	pH	6.8
H_2S	49 mgm./l.	T.S. @ low red heat	49.1 gms./l.

TABLE 10
Examination of Deposits from Brine Injection Systems

FIELD	Rice Co., Kansas	Rice Co., Kansas	Butler Co., Kansas
Source of sample	Injection tubing	Brine pit	Brine line to well
Brine through system	Arbuckle	Arbuckle	Arbuckle and K. C. Lime
	Percent	Percent	Percent
Oil	8.9	5.9	19.2
Sulfur	51.1	11.7	8.1
FeS	24.6	3.3	9.9
$SrSO_4$	....	....	50.2
$CaCO_3$	8.1	60.7	8.7
$MgCO_3$	2.3	3.2	0.6
$CaSO_4$	1.2	1.9	0.8
Water-sol. Salts	0.6	0.9	1.7
Inert (sand, silt)	2.9	12.2	0.2
Total	99.7	99.8	99.4

TWO GREAT SYSTEMS IN *Gas Lift!*

Surface Controlled or Automatic in One Installation

Bryan Surface Controlled System

SURFACE CONTROL IN A REMOVABLE VALVE: run it in on a wire line, pull it out with a wire line. NEW, ADVANCED: stops tubing pulling.

Intermitting FROM THE BOTTOM to increase production, to reduce ratios.

THE SYSTEM: Unload to bottom with BRYAN Universal Valves; all fluid in the casing transferred into the tubing through the Unloading Chamber (not through your valves); Run the Drop Valve (after unloading) and produce the well as desired with the Surface Controlled Bellows Valve in the Drop Valve! If you want all the oil, THIS IS THE SYSTEM TO USE!

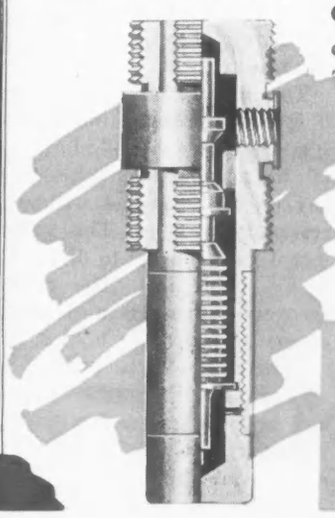
ENGINEERS: Don't overlook this system; if you are running closed installations to relieve the formation of back pressure, to promote production, THEN USE this removable valve that works IN THE BOTTOM. CONTROLLED RATIOS!

CHECK IT: Low Pressure operation at the top of the well (lift is the least) successively increasing pressures as depth increases. IF YOU WANT LOW RATIOS, CONSIDER THIS OPERATION!

ONLY ONE VALVE IN OPERATION AT ANY TIME. NO GUESSWORK AS TO FLOWING LEVEL.

Unit type surface controller to regulate casing pressures.

YOU can have low RATIOS with THIS Surface Control Valve; you can GO TO BOTTOM. If you are interested in getting all the oil, reducing ratios, reducing lift costs, *Investigate This System:*



Bryan Universal Automatic System

Thousands of Universal Flow Valves with the Drop Valve are in successful operation. THIS IS THE SYSTEM Major and Independent Operators alike are using.

IT WILL unload any well, automatically and successfully; give sensational LOW RATIOS consistently; prevent cutting out your flow valves by using the unloading chamber; all fluid in the casing is transferred to the tubing through the chamber, NOT THROUGH THE VALVES . . . produce low pressures at the formation to promote production . . . give depletion operation . . . operate under proration.

The only Removable Intermitter in Gas Lift!

MR. ENGINEER: You can get behind this system; HERE'S WHY:

Ratios based on 100'/Bbl/ thousand feet of lift.

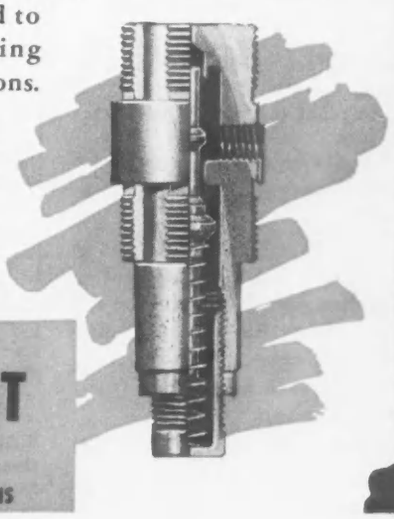
Pressure to lift based on 60-80 lbs./M ft. of lift.

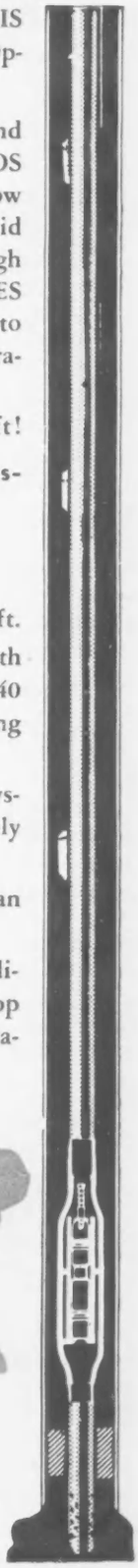
Pressure at the formation when operating with the Standard Universal Valve, Based on 30-40 lbs./M. ft. of lift. Lower, if desired, by changing valves in the DROP VALVE.

No surface intermitters required with this system . . . entirely automatic! It will positively work in ANY WELL.

No limitation as to rates or depth other than capacity of tubing and available pressure.

You cannot make the mistake of wrong application with this system for the reason the drop valve can be adjusted for any type of operation desired to meet changing well conditions. YOU CANNOT DO MORE IN GAS LIFT. INVESTIGATE THIS SYSTEM.





BRYAN GAS LIFT
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Oil Production by Gas and Flooding

Part 5 Pressure Maintenance With Gas

By PARK J. JONES
Consultant, Houston

OIL recovery at the economic limit as to injection gas-oil ratio varies primarily with the barrels of oil accumulated prior to breakthrough of injected gas. Breakthrough oil recovery is controlled by the location and completion of producing wells. The rate of oil production after breakthrough of gas may be limited considerably by insufficient injection capacity.

Breakthrough Oil Recovery

Consider the displacement of a reservoir liquid by injected gas. Let the displacement be at a pressure which is equal to, or greater than, the saturation pressure for the oil in any reservoir which has no primary gas cap and no encroachment of water. Under these conditions the composition of production is uniform until injected gas appears in production. The cumulative oil recovery at the time injected gas reaches a producing well is called the breakthrough recovery and is defined by

$$C = p(ah)m \qquad (1)$$

where

ah = acre-feet of oil pay invaded by injected gas
p = in place oil, barrels per acre-foot
m = displacement factor
C = cumulative oil recovery, barrels.

As gas tends to migrate updip, it is usually advantageous to displace oil in the downdip direction. Let (pah) be the in place oil on the updip side of producing wells. Then the breakthrough recovery X expressed as a fraction (C/pah) of in place oil is given by

$$X = Im \qquad (2)$$

where I is the invasion factor, that is, the acre-feet of pay invaded by injected gas at breakthrough divided by the acre-feet on the updip side of producing wells.

Operating Expenses vs. Gas-Oil Ratio

The oil recovery X without producing injected gas varies with per-bed permeability ratios and with the location and completion of wells. Permeability and well completions also control the production of injected gas after breakthrough. However, per-bed pay thickness and permeability are not mappable. So the prospective ratio of injected gas per barrel of produced oil is not known definitely.

On the other hand, field experience indicates that the volume of gas required to achieve a given oil recovery varies greatly with the oil recovery X prior to breakthrough of injected gas. If injection ratio is limited economically to, say, 20 MCF per barrel of produced oil, the oil recovery at economic limit varies primarily with the barrels of oil accumulated prior to breakthrough of injected gas.

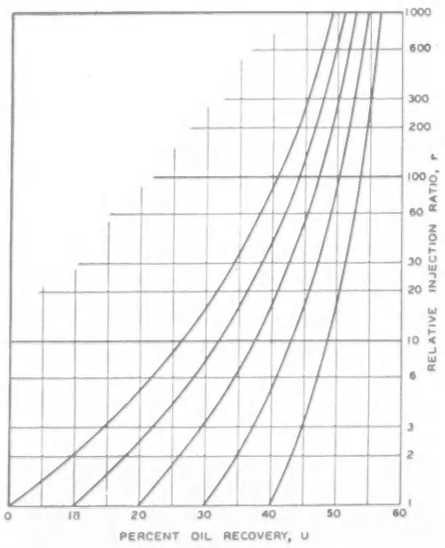

FIGURE 5-1. Relative injection ratio vs. breakthrough and ultimate oil recoveries; r times the basic r_o cubic feet per barrel is the required injection ratio for maintaining reservoir pressure.

The control of gas-oil ratios is limited to the location, number and completion of wells. Producing wells can be shut-in after breakthrough in order to control gas-oil ratios. But a shut-in well cannot produce oil. So in order to maintain an oil producing rate with a given number of wells, the job is to maximize X the oil recovery prior to breakthrough of injected gas.

Unit of Gas Requirements

If one barrel of oil occupies b_o barrels of reservoir space, the minimum gas requirement r_o in cubic feet per barrel of oil is defined by

$$r_o = 198.4 b_o P/TZ \qquad (3)$$

For example, r_o may be 1000 cubic feet per barrel of oil aside from producing any injected gas.

The in place oil is S/b_o barrels where S is the barrels of invadable reservoir space occupied by oil. Let C barrels of oil be accumulated without producing any injected gas and without declining reservoir pressure. The volume of injected gas required to displace C barrels is Cr_o cubic feet. The cumulative oil recovery represents a fractional oil recovery U which is Cb_o/S of in place oil.

Suppose the S/b_o barrels of in place oil could be displaced without producing any injected gas and without declining reservoir pressure. The total gas requirement would be r_oS/b_o cubic feet.

Denote the r_oS/b_o basic gas require-

2½ years ago this advertisement told of 1,471 days of continuous service for a string of "K" Monel sucker rods installed in a corrosive Texas well . . .*

Never give corrosion an even break
. . . use SUCKER RODS of "K" Monel
When a sucker rod broke every 50 days . . .
. . . and the entire string had to be replaced every 5 months . . .
. . . operators of Arrington No. 2 well in the Howard Glasscock Field at Big Spring, Texas, made a wise move.

NOW...YOU CAN CHANGE THAT RECORD TO 2,397 DAYS!

Until November 1941, operators of Arrington No. 2 well in the Howard Glasscock Field at Big Spring, Texas, had sucker rod problems aplenty.

The advertisement shown above told about them. It told how a rod broke every 50 days. How the entire string had to be replaced every 5 months.

Then came "K" Monel

More important, though, was the story of how the situation changed after November 26, 1941. That was the date a string of ¾" "K" Monel sucker rods made by W. C. Norris Manufacturer, Inc., Tulsa, Okla., went into Arrington No. 2.

The "K" Monel string had been in continuous use for 1,471 days when E. G. Rodman, owner of the lease, said:

> *"The string of "K" Monel rods installed in 1941 was used every day—24 hours a day—in 2½" tubing with a 2¼" barrel until July 1944, when the 2½" tubing was replaced with 3" tubing and a 2¾" barrel (42" stroke—20 strokes per minute). Despite the considerable load increase . . . we have continued to use the same rods without a single break or shutdown due to rod failure. In addition, the rods appear to be as good as new."*

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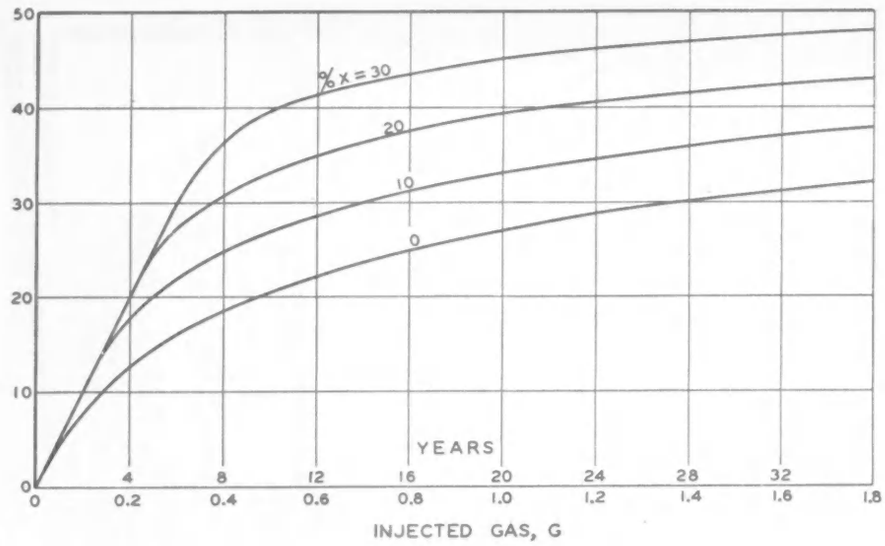

FIGURE 5-2. Cumulative oil recovery vs. injected gas and time for a 5 percent per year initial rate of oil production and a uniform rate of gas injection.

ment by unity. Then if a fraction U of in place oil were recovered without producing any injected gas, the fractional gas requirement G would equal U, for

$$U = \frac{Cb_o}{S} \text{ and } G = Cr_o/(r_oS/b_o) = U$$

But if some injected gas is produced with an increment ΔU in oil recovery, then the gas requirement ΔG for the increase ΔU in oil recovery is defined by

$$G = r\Delta U \qquad (4)$$

where r is some multiple of r_o, the basic cubic feet of injected gas per barrel of produced oil. For instance, if r_o were 1000 cubic feet per barrel and 10 percent of in place oil were produced with an average injected gas-oil ratio of unity, that is, one MCF per barrel aside from solution gas and above the 1000 required to displace one barrel of oil in a reservoir, r would equal 2.0 and G would be 20 percent.

Injected Gas-Oil Ratio Basis

As the cost of producing oil by gas injection depends largely on not producing injected gas, it is convenient to express oil recovery in terms of (1) injected gas and (2) the ratio of injected gas in production. Thus

$$U = \Sigma\Delta U = \Sigma\left(\frac{\Delta G}{r}\right) = G/R \qquad (5)$$

from which R the average injected gas per barrel of produced oil is

$$R = G/\Sigma(\Delta G/r) \qquad (6)$$

Oil Recovery vs. Injected Ratio

After breakthrough, the relationship between the increase in oil recovery per unit of gas injection is defined by

$$\frac{dU}{dG} = \frac{1}{r} \qquad (7)$$

where r is the injection ratio aside from solution gas and a change in reservoir pressure.

As already noted, injection ratios are not known definitely. However, the probability is that injection requirements are not likely to be less than the ratios defined by

$$r = \left[\frac{0.6 - X}{0.6 - U}\right]^4 \qquad (8)$$

where X is the breakthrough oil recovery and U is oil recovery at any time after breakthrough. Aside from economic limits as to gas-oil ratios, the displaceable oil is about 60 percent of in place oil on the updip side of producing wells. The difference (0.6 — X) is the displaceable oil at the time of breakthrough. The difference (0.6 —U) is the remaining displaceable oil when the injection ratio is r. In order to achieve a 60 percent recovery, the invasion factor would have to be 100 percent, the gas-oil ratio would have to be on the order of one million cubic feet per barrel and reservoir pressure would have to be maintained at, or above, saturation pressure.

The curves in Figure 5-1 are solutions of equation (8). Relative injection ratio r is plotted against oil recovery for several breakthrough recoveries. Multiply the basic gas requirement r_o by the relative injection ratio r to obtain the required cubic feet of injected gas per barrel of produced oil. The data are for reservoir pressure at, or above, saturation pressure and for reasonable oil to gas viscosity ratio.

Oil Recovery vs. Total Injection

Suppose the volume of injected gas is G times r_oS/b_o cubic feet. The corresponding oil recovery is not likely to ex-

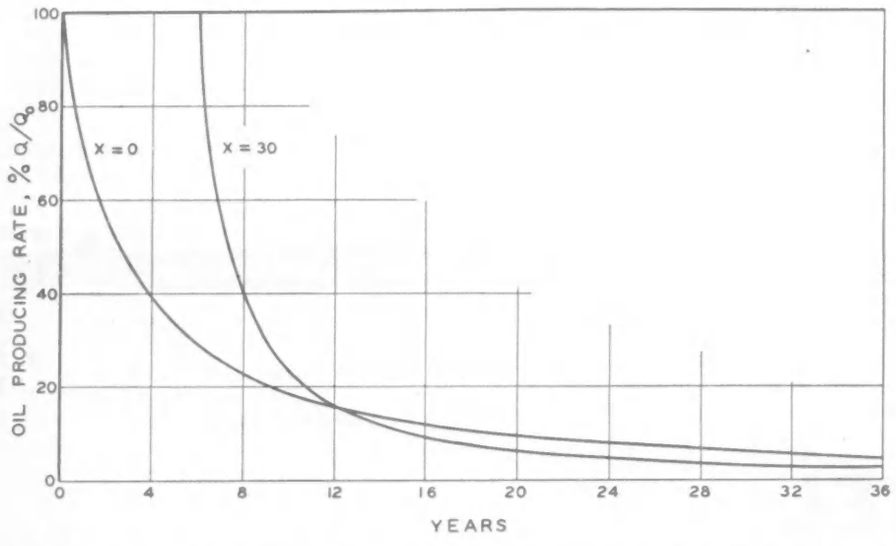

FIGURE 5-3. The relative rate of oil production for a 5 percent per year initial rate vs. time and breakthrough oil recovery X; the rate of gas injection is uniform.

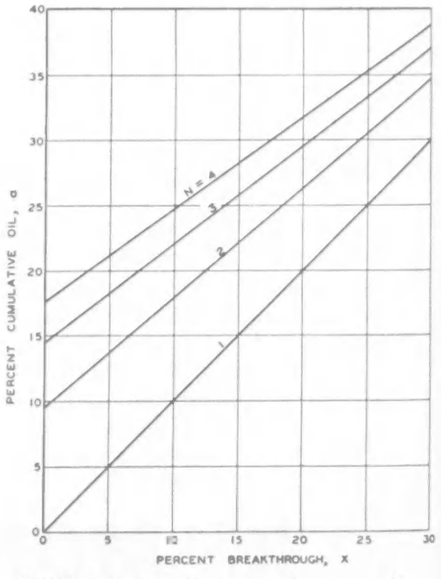

FIGURE 5-4. The oil recoverable at a uniform rate vs. breakthrough recovery X and relative injection capacity N.

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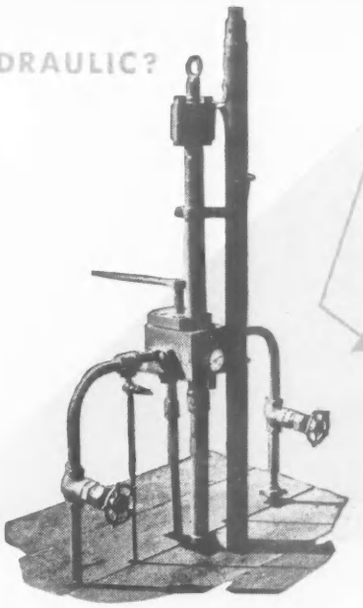

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ceed the recovery defined by

$$\int_X^U \frac{dU}{(0.6-U)^4} = \frac{G-X}{(0.6-X)^4} \quad (9)$$

from which

$$G = X + \frac{(0.6-X)^4}{3(0.6-U)^3} - \frac{0.6-X}{3} \quad (10)$$

The curves in Figure 5-2 are solutions of equation (10). In a limestone reservoir having thin beds of high permeability, injected gas may break through practically at the outset. The zero breakthrough curve shows a 32 percent oil recovery when the total injected gas is 1.8 volumes. A sandstone reservoir having a comparatively uniform permeability may have a 30 percent breakthrough. The indicated oil recovery is about 48 percent for an injection of 1.8 volumes.

Cumulative Oil vs. Time

Let Q_g be a uniform daily rate of gas injection. Then $365Q_g$ is the annual rate and

$$\frac{365Q_g b_o}{Sr_o} = \frac{dG}{dy} = Q_o \quad (11)$$

For instance, if r_oS/b_o were a hundred billion, and plant capacity were provided to inject at the rate of five percent per year, the daily rate of gas injection would be 13.7 million cubic feet. The corresponding rate of oil production Q_o would also be five percent per year aside from production of injected gas or a change in reservoir pressure.

The rate of increase in cumulative oil recovery dU/dy is the rate of oil production Q at any time. Accordingly,

$$\frac{dU}{dy} = Q = \frac{Q_o}{r} \quad (12)$$

where r is the relative injection gas-oil ratio.

At the time of gas breakthrough, y equals X/Q_o years. At some later time, oil recovery U is given by

$$\int_X^U \frac{dU}{(0.6-U)^4} = \frac{y - \frac{X}{Q_o}}{(0.6-X)^4} Q_o \quad (13)$$

from which

$$y = \frac{1}{Q_o}\left[X + \frac{(0.6-X)^4}{3(0.6-U)^3} - \frac{0.6-X}{3}\right] = \frac{G}{Q_o} \quad (14)$$

Figure 5-2 shows cumulative oil recovery for the first 36 years when the initial rate of oil production is five percent per year of in place oil and the annual rate of gas injection is uniform.

Oil Rate vs. Time

The cumulative oil recovery U at any time y is given by

$$U = 0.6 - \left[\frac{(0.6-X)^4}{3yQ_o - 4X + 0.6}\right]^{1/3} \quad (15)$$

As the rate of oil production Q at any time y equals dU/dy, it may be verified by differentiating equation (15) that

$$Q = \frac{Q_o(0.6-X)^{4/3}}{(3yQ_o - 4X + 0.6)^{4/3}} \quad (16)$$

So the prospective rate of oil production expressed as a fraction of the initial rate may be estimated from

$$\left[\frac{Q}{Q_o}\right]^{3/4} = \frac{0.6-X}{3yQ_o - 4X + 0.6} \quad (17)$$

The curves in Figure 5-3 are solutions of equation (17) for a five percent per year initial rate of oil production.

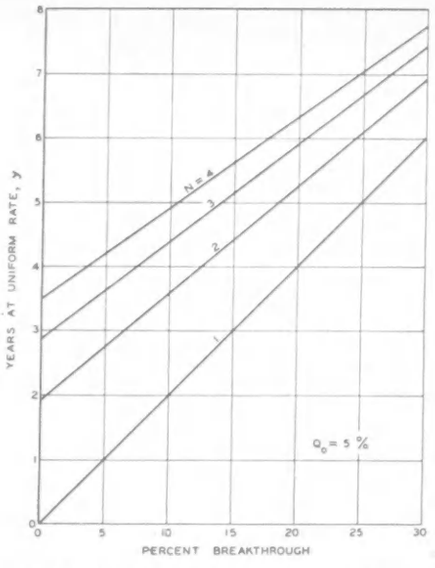

FIGURE 5-5. Years during which oil can be produced at 5 percent per year vs. breakthrough and relative injection capacity.

More Injection Capacity

If an injection capacity is N times the initial requirement, oil production can be maintained at a uniform rate Q_o until the injection ratio is N times the initial ratio. Let 'a' equal the cumulative recovery at the time an oil producing rate starts declining. Then by equation (8)

$$a = 0.6 - \frac{0.6-X}{N^{1/4}} \quad (18)$$

The difference between the lines in Figure 5-4 shows the increase in cumulative oil recoverable at a uniform rate for zero to 30 percent breakthrough and injection capacities equal to 2, 3 or 4 times the initial requirement.

The number of years y during which oil can be produced at a uniform rate Q_o is a/Q_o. The difference between the lines in Figure 5-5 shows the number of additional years during which oil can be produced at five percent per year of in place oil for injection capacities equal to 2, 3 or 4 times the initial requirement.

At the time the oil producing rate starts declining,

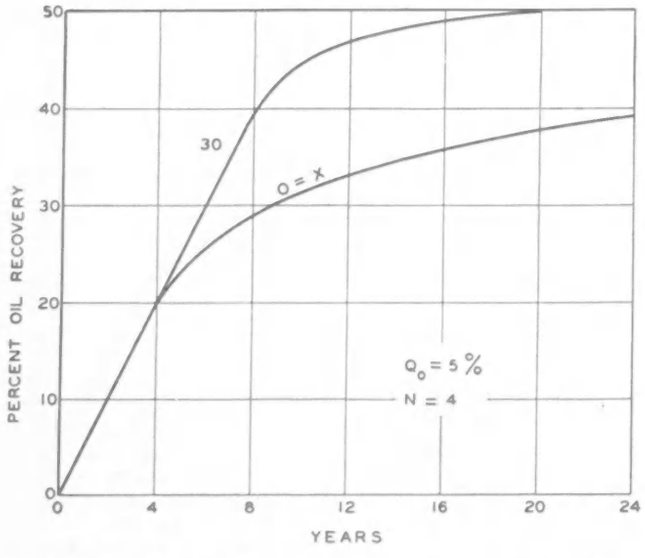

FIGURE 5-6. Cumulative oil recovery vs. time for a zero and 30 percent breakthrough, 5 percent per year initial oil producing rate and a relative injection capacity of four times the initial injection rate.

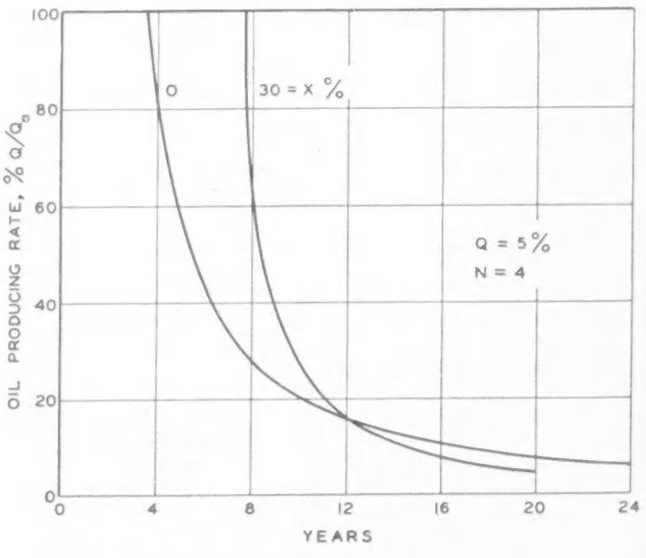

FIGURE 5-7. The relative rate of oil production vs. time for a 5 percent per year initial oil rate and a relative injection capacity of four.

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$$r = N = \left(\frac{0.6 - X}{0.6 - a}\right)^4$$

The probable declining oil producing rate is given by

$$Q = NQ_o/r$$

where

$$r = \left(\frac{0.6 - X}{0.6 - U}\right)^4$$

Accordingly,

$$\frac{dU}{dy} = Q = \left(\frac{0.6 - U}{0.6 - a}\right)^4 Q_o$$

from which

$$U = 0.6 - \left[\frac{(0.6 - a)^4}{3yQ_o - 4a + 0.6}\right]^{1/3} \quad (19)$$

for values of y equal to, or greater than, a/Q_o.

In terms of breakthrough and relative injection capacity,

$$U = 0.6 - \left[\frac{(0.6 - X)^4}{3N(yQ_o - 0.6) + 4(0.6 - X)N^{3/4}}\right]^{1/3} \quad (20)$$

The curves in Figure 5-6 are solutions of equation (19) for a five percent per year initial oil producing rate. The injection capacity is four times the initial requirement. The injection life for a 20 MCF per barrel economic limit is decreased from 35 to 13 years for a zero breakthrough and from 23 to 13 for a 30 percent breakthrough.

The probable declining oil producing rate is given by

$$\left[\frac{Q}{Q_o}\right]^{3/4} = \frac{0.6 - a}{3yQ_o - 4a + 0.6} \quad (21)$$

or

$$\left[\frac{Q}{Q_o}\right]^{3/4} = \frac{0.6 - X}{3(yQ_o - 0.6)N^{3/4} + 4(0.6 - X)} \quad (22)$$

Figure 5-7 shows the relative oil producing rate for a five percent per year initial rate and a fourfold injection capacity. On the assumption that pressure were maintained to a 20 MCF per barrel injection economic limit, a comparison of the unit and fourfold injection capacities would be as follows:

Breakthrough, %	Zero		30	
Injection, % per year	5	20	5	20
Life at 5%/yr. oil rate, yrs.	0	3.5	6	7.8
Cumulative oil at uniform rate, %	0	17.5	30	39
Approximate total life, yrs.	35	13	23	13
Ultimate oil recovery, %	32	32	46	46
Life at declining oil rate, yrs.	35	9.5	17	5.2
Cumulative oil at declining rate, %	32	14.5	16	7.0
Final oil rate, % per year	0.25	1.0	0.25	1.0

If the unit injection rate were 15 million per day, the fourfold injection rate would increase from 15 to 60 million per day in the first 3.5 years for a zero breakthrough and between the 6th and 8th years for a 30 percent breakthrough. Oil rates are in percent per year of the oil in place on the updip side of producing wells provided the invasion factor equals unity.

(TO BE CONTINUED)

Problems of Water Injection in Wells

■ CONTINUED FROM PAGE 144

bottom of gathering pits which hold Arbuckle brine for a sufficient period to allow calcium carbonate precipitation. The rather hard scale from the brine line resulted largely by mingling brine from the Kansas City oil zone with that from the Arbuckle oil zone. Brine from the upper, or Kansas City zone, contains strontium, while that from the other zone contains sulfate. Thus, formation of the insoluble deposit was a quite natural chemical reaction. This problem called for prevention of deposit by using separate lines to disposal wells and better separation of oil.

Correlation Saves Time

The correlation of operating conditions with type of sludge deposit to be expected is a time-saving aid in sludge prevention or removal problems. Methods for the examination and identification of such materials have recently been outlined in considerable detail.[4,5]

Any discussion of sludge troubles in salt water disposal would not be complete, in view of very recent developments in western Kansas, without some mention of observed conditions in brine disposal systems which receive their waste brine from wells being treated with formaldehyde. For a considerable period, field men have reported that increased clogging of waste water lines seemed more evident where formaldehyde was being used for anti-corrosion treatment. Preliminary examination of several of these deposits gave results similar to those shown on the material from the injection tubing, Table 10. In other words, nearly 100 percent of the material could be accounted for by the usual oil, sulfur, calcium carbonate, iron sulfide and inert matter. However, the peculiar odor produced by burning the sludge led to the belief that small amounts of other compounds were present. More recently, a deposit was examined which caused plugging of injection tubing. This material was almost oil free and found to contain 65 percent sulfur, in the combined state, after small amounts of oil, calcium carbonate and iron compounds had been removed. Since the treated material was almost entirely volatile, organic compounds other than sulfur were indicated.

Further examination has shown the presence of appreciable carbon, hydrogen and oxygen in addition to the sulfur. The possibility that this product could be derived from the oil seems worthy of consideration. However, it seems more probable that it is a reaction product of hydrogen sulfide and formaldehyde because of the high sulfur ratio.[6] The exact nature of this deposit and the extent of operating problems due to its formation are not well understood at present. The existing conditions in some salt water disposal systems are believed to indicate near-term operational difficulties of magnitude sufficient to merit considerable investigation in an effort to find effective methods of removal and prevention. Since this organic-sulfur deposit is only slightly soluble in known solvents, it would appear that preventive methods would be the more practical. The deposit from the injection tubing appeared to be a relatively pure organic-sulfur compound. However, it does not constitute a large portion of the sludge from the waste brine lines and gathering pits. Rather, in relatively small proportion to total deposit, it apparently provides a nucleus for agglomerating particles of other materials, thus exerting an accelerating effect on sediment accumulation.

Much operating trouble in the form of plugging deposits has been anticipated and thus avoided by the chemist. This result, however, was accomplished only after considerable experience in correlation of more significant factors. In other words, painstaking chemical analyses were of no value but the services of the chemist became indispensable after he had learned to treat rather lightly the almost omnipresent oil, sulfur, water, water-soluble salts and wind-blown inert material. These materials, especially oil and dirt, represent operating problems and are recognized as such by the field engineer. Cooperation of engineer and chemist is thus essential for solution of many problems in salt water injection. It is indeed, gratifying, after more than ten years of large-scale salt water injection in wells, to conclude that the teamwork of field engineer and chemist has reached a state where samples to the chemist are accompanied by comprehensive description of equipment and operation. Armed with these data, the chemist is enabled to save a great deal of laboratory time on things which are usually most difficult of analysis and least useful as criteria.

This article was revised for WORLD OIL from a paper presented at the 114th meeting of the American Chemical Society, Division of Water, Sewage and Sanitation Chemistry, St. Louis, Mo., September 6-10, 1948.

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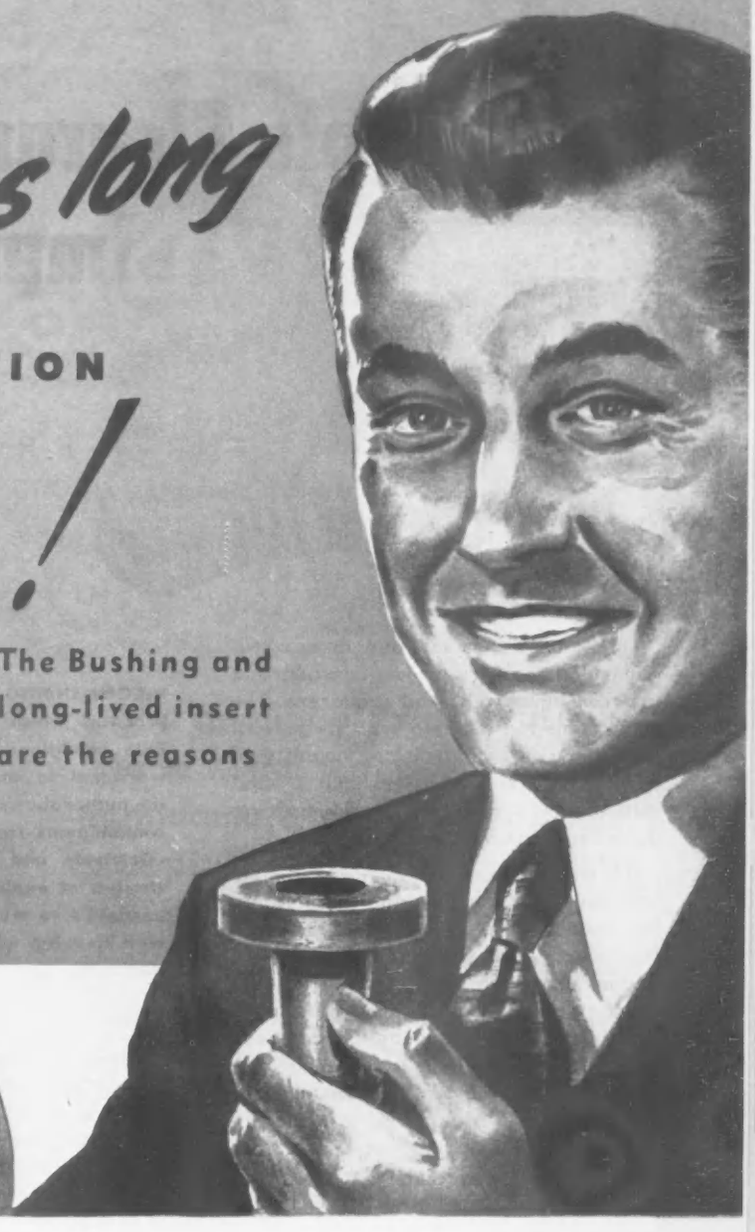

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Shot-Hole Clearance Improves Oil Recovery

By F. R. COZZENS
Field Foreman, Equity Oil & Gas Company, Stockport, Ohio

RECOMMENDING precautions and practices which will improve shot-hole conditions before they have worsened to demand a workover, the author shows how down-the-hole contaminants can be removed most effectively and economically. Light charges of explosive, carefully proportioned to well sand face, aid in well cleaning without complete dismantling.

THE most important route on any secondary oil recovery project is production between input wells and producers. The production route, along with its pattern of feeder-lanes, controls the quantity of oil that is transported through a sand structure, and also the cost and effort required for its transportation.

Through the employment of certain well-shooting practices and reconditioning methods, it is now generally possible from a practical standpoint to establish within an oil-bearing formation an adequate production route that would likely remain trouble-free indefinitely provided that oil, and oil alone, were to be conveyed over its course. Unfortunately, this is not the case. Along with pressured-in oil come, not only gas, air, and water, but also a wide variety of solids, semi-solids, bacterial growth, surface elements, etc., scarcely noticeable at first but increasing in quantity as pressures develop, until they normally occupy anywhere from 5 to 30 percent of the drainage space. The majority of these substances, or the most important among them, originate from disintegration and various chemical actions within the sand structure. As pressure or driving-energy builds up, sand pores and capillaries are constantly being made larger and less resistant.

"Floating Sand"

During this process, sand-particles are loosened, along with fragments of the cement-like binder which holds the particles in place. This latter substance is by far the most active and versatile constituent in the group, and appears to have the ability to unify the various other substances into a continuous, ropy mass, which is conveyed along the drainage system with the pressured oil. Eventually, it reaches the producing area of pumping wells. The shot hole of each producing well is a normal outlet for the drainage system and therefore a reservoir for oil and a catch-basin for sediment. As long as the shot hole remains clear and unobstructed, residue drainage into it is continuous, and no trouble is experienced. To a limited extent, sediment-burden is released through the pump, but eventually the load becomes excessive, and accumulating residue undergoes a very important change. The heavier, more gritty portions settle out, leaving a dense soapy scum, commonly known as "floating sand." Splotches of it soon appear in drip-barrels and tanks with the pumped oil.

This so called "floating-sand" has the dual ability to remain suspended in either oil or water, and to adhere and cling tenaciously to the walls of the shot-hole and to pumping equipment when the fluid is withdrawn. As the fluid-column in the shot-hole rises and falls during pumping periods, this portion of the residue continues to congeal and thicken, and while the pumper is being be-deviled with clogged working barrels and sanded-out cups, a sphere of resistance is building up over the sand face.

If the well is further neglected, head-pressure increases in the producing zones until finally, there is a "break-through" either by channeling into the shot-hole, or in various directions around it where resistance is less. Whichever happens, there is a clogged drainage system and a damaged well.

Opinions among secondary oil recovery operators differ as to how much residue-burden a pumping well can carry without curtailing the rate of oil flow or necessitating a costly repair job. Much depends upon the nature of the well, pressuring agent, and shape and capacity of the shot-hole. Those operators who follow production trends very closely believe, however, that the danger point is reached when any floating residue begins to appear in the pumped oil, and corrective measures are started at once. At this early stage, affected wells are often cleared, without removing tubing and rods, by circulating a 15 percent solution of hydrochloric acid (with inhibitors) through the shot-hole. Certain constituents (calcium, scale, mineral salts, etc.) of the "floating" residue which creates most of the damage, are acid-soluble.

While these elements comprise only a very minor portion of the residue-bulk, their dissolution is usually sufficient to break down the composition of the film over the sand-face, causing it to loosen, or slough off. Agitation by the circulating fluid generally reduces the mass to a state where it can be lifted and brought to the surface through the pump.

Acid Treatment Method

Unless the tubing is seated on a packer, the acid-treatment is carried out by pouring down the casing (around the tubing) 100 to 250 gallons of acid solution, the quantity of fluid being governed by capacity of the shot-hole. The lead line of the well is then connected to discharge into the casing, and the well is pumped continuously for six to eight hours, after which the lead line is disconnected from the casing, and the shot-hole pumped dry as possible.

Two or three applications are given in the same manner on successive days, and the final acid circulation is followed by

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washing out the shot-hole with water. If there is some evidence of wax or paraffin deposits, the first acid application is often preceded by circulating heated water through the shot-hole. Waxes are not soluble in acid, and may hinder its action on other substances unless removed by a heating agent before the acid is applied.

In these very early stages of drainage impairment, wells which are receiving considerable pressuring medium along with the oil and residue are often benefited by establishing temporary back pressures in the shot-hole. Such wells are closed in and allowed to head-up for periods of 24 to 36 hours, after which they are opened and pumped out. This practice is repeated six to eight times over the course of a month, and tends to stimulate a breathing action through the pores of the sand-face. Alternating energy, thus created, keeps residue in motion and induces better drainage. Where it is not possible or advisable to back-pressure wells, drainage elimination can also be encouraged by inducting more driving-energy into nearby inputs, while producing wells in the immediate area are left open and pumped for continuous periods of 24 to 36 hours. After a half-dozen or more off-schedule pumping periods, the regular pumping schedule is resumed. This practice is not recommended, however, for areas in which water-banks or marginal floods are known to exist, nor for sand-zones where channeling is excessive. Residue clearance is impossible in badly-channeled zones until the channels are repaired or plugged off.

While anywhere from one gallon to a barrel or more of residue can be lifted through the pump from an affected shot-hole during clearance treatment, it must be kept in mind that the pump is effective only in the very early stages of shot-hole impairment. Even at these stages, it is generally necessary to remove and clean the tubing and working barrel, and replace cups during intervals between pumping-out periods, because dense portions of residue can seldom be stirred and liquefied sufficiently to enter and clear the pump.

Use of Explosives

Since the average well in a pressured area is generally neglected far beyond the initial stages of impairment, the most practical and effective treatment is a light charge of explosives, usually solidified nitroglycerin, commonly known as gelatin or gelamite. This form of treatment requires removal of tubing and rods, but it is seldom necessary to lift the casing or remove packers. Many of the shots are placed within two feet of a casing shoulder or packer without any resulting damage.

The treating procedure is to pump out the shot-hole, and remove pumping equipment. Approximately 100 gallons of water are poured down the casing. Explosive packs are usually made up of 4x16-inch cartridges, loaded into a 4½-inch diameter torpedo shell, with cap and connections taped in. Size or weight of the shot is a matter of choice, the general rule being 7.5 pounds of solidified nitroglycerin, 100 percent strength, for each foot of producing sand; 3.32 pounds of solidified nitroglycerin being equivalent to approximately one quart of liquid nitroglycerin. Since base of the shell is usually kept two feet off bottom, and top of shell two feet below top of sand-column (because of casing), weight of these packs seldom exceeds 40 pounds. No tamping is used over the shot after it is lowered into position, and detonation is accomplished by means of a "go-devil" or commercial detonator, dropped down the casing. The shooting practice is often carried out by the lease foreman and crew, but it is far better and safer to have it done or supervised by a competent well-shooter. Although solidified nitroglycerin is less sensitive than liquid forms, it is by no means fool-proof.

Spray-Gun System

In shallow wells, considerable residue is forced to the surface by blasting energy. The remainder is often removed, and the shot-hole washed down by bailer, fitted with a spray gun. The sand-line operates over a pulley at the top of the casing-pole, and is spooled on a reel attached to, and powered by a tractor. The initial part of the process is carried out by replacing the bailer dart-valve with a spray-gun. The bailer is then filled with water and lowered into the well where it is tripped at the desired depth, and contents are jetted in various directions against the walls of the shot-hole. This process is repeated three to five times, after which the spray-gun is removed, and the well bailed out.

On deeper wells (1000 feet or more), a string of light cleanout tools or a small mobile spudder is faster and more economical for this type of work. When these outfits are used, residue is generally stirred by the drill. Very little water is poured in. Faster and more effective agitation is accomplished by holding the bit a few inches off bottom. After the bulk of the residue has been thoroughly stirred and bailed out, the shot-hole is washed out several times with clean water. These cleaning processes generally can be accomplished at less than one-third the cost of a customary cleanout job, and the well placed back in production within three days.

Upon completion of a cleanout job, broken or faulty pumping equipment should be repaired so that wells need not be off pump over long periods of time. The moment is also opportune for repairing channel damage to shot-holes, or for closing avenues through which shot-hole production escapes into thief formations. Many such jobs can now be done quite economically by the use of recently developed plugging agents, which are also useful in sealing off watered or otherwise undesirable sand zones. Pressures necessary for inducting and seating these agents are provided by compressors, and most plugging or sealing-off jobs can be accomplished by a lease crew. Many wells can be benefited by increasing the capacity of the shot-hole by explosives, or by extending pockets (if none exist) to depths 50 to 100 feet below the base of the producing sand.

Maintaining Clearance

Where excess water or thief formations are encountered, pockets are cased, and the casing cemented. Pockets provide additional space for residue, keeping much of it out of the shot-hole, and if working barrels are located at, or a little below, the top of the pocket pumping can be done so that oil, instead of water, can be held in constant contact with the sand-face surface. This is especially beneficial in residue-clearance where perforated liners are being used.

After a shot-hole has been cleared of excessive residue, and the drainage route opened, a very determined effort should be made to retain the beneficial effects. While little or nothing can be done to prevent the formation of residue in a body of sand, much can be accomplished in practical ways to prevent its interference with the flow of oil.

Strict adherence to a good operating schedule is a necessity, with close attention being given to the behavior of producing wells. Sharp fluctuations in production should be checked for causes, and oil samples from each well examined frequently for residue content. Experimental pumping and pressuring methods bear close watching for possible bad effects on drainage elimination. Field-tested pumping practices promote and encourage the continuous unloading of residue burden into the shot-hole; therefore, working-barrels should be kept clean and worn cups replaced so that as much as possible of the burden (as formed) can be lifted through the pump. Free drainage, accomplished by practical methods, retards channeling, lessens pressure-waste, and provides a more receptive pressure-pattern. When pressure-patterns function normally, a more stabilized and uniform capillary action is established through the sand-structure. Consequently, more oil is transported over the production route, at a faster rate, with less expense.

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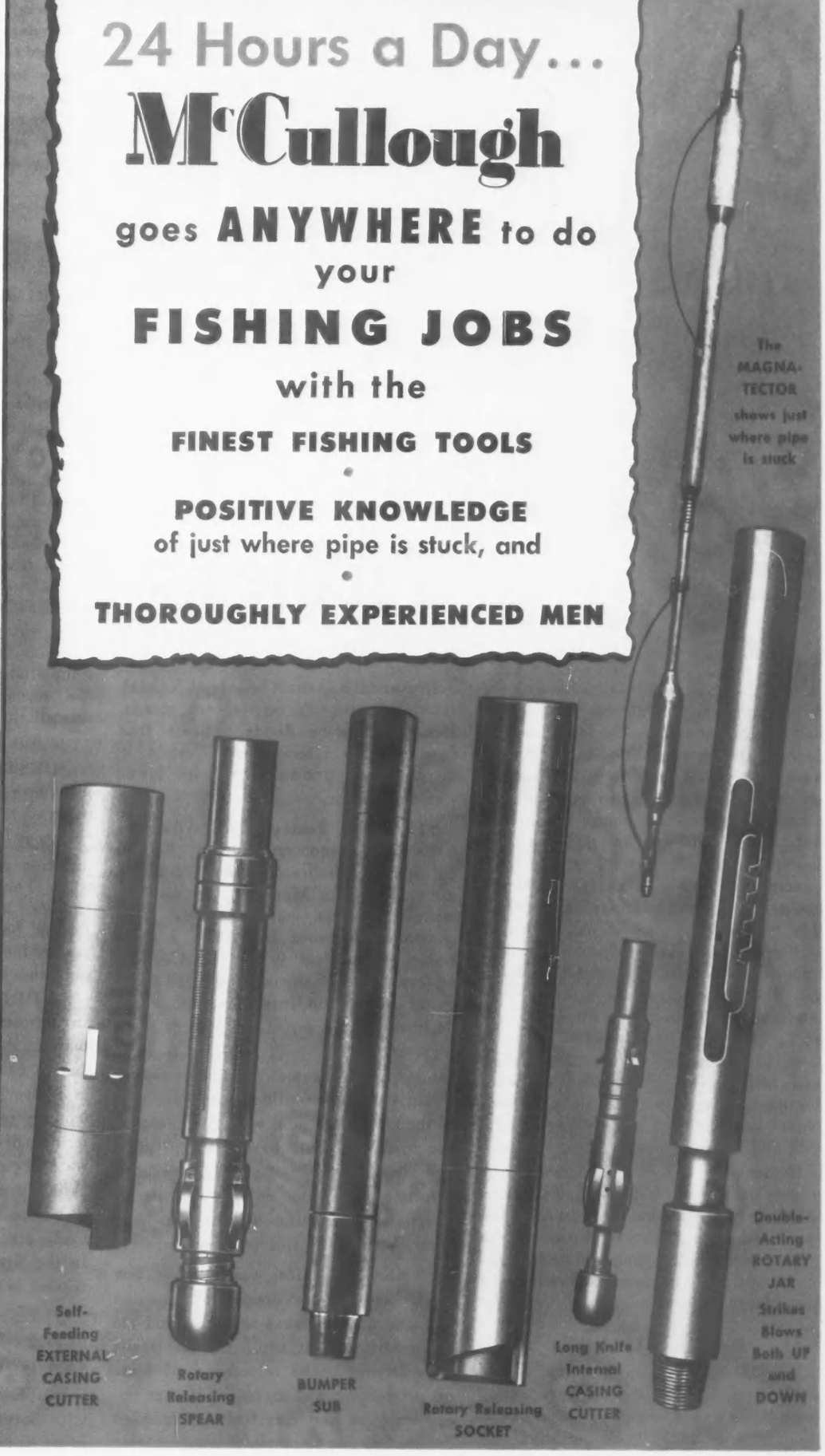
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Meeting of Oklahoma-Kansas water-flood operators.
Photo courtesy *The Oil Digest*

A SYMPOSIUM of the "question and answer" type is often effective in bringing out details on a subject which fail to receive due emphasis in a formal paper on the subject. The ensuing discussion touches on many points in water-flood practice, and combines the experience of many operators.

Water-Flood Problems

FOR the past two years oil producers in northeastern Oklahoma and southeastern Kansas engaged in secondary recovery through water-flooding operations have met periodically to hear speakers on related subjects and to exchange information. A recent meeting at Bartlesville, Okla., featured a question and answer program on which a "panel of experts" selected from among petroleum engineers and oil producers participated. The "moderator" was D. B. Taliaferro of the U. S. Bureau of Mines at Bartlesville. The "experts" included Carl Pate, Oil Field Research Laboratories; Kurt Andresen, The Carter Oil Company; L. L. Brundred, Brundred Oil Corporation; E. C. Earlougher, Earlougher Engineering; Foster Pyle, Sohio Petroleum Company; Marion Stekoll, Stekoll Petroleum Company; and J. L. Wiley, Wellsville Oil Company.

Because the subjects discussed cover a wide field in water-flooding techniques WORLD OIL feels that the presentation in question and answer form of the transcript of the meeting will be of service to operators engaged in this form of secondary recovery.

Restricting Production

QUESTION: Is the practice of controlling or restricting the production from wells in a flowing flood effective in increasing the recovery of the flood?

EARLOUGHER: The question is still controversial and must be solved for each individual property on its own merits. Results of some floods indicate that flowing wells intermittently results in increased oil production with lower water-oil ratios.

STEKOLL: Tests on Bartlesville sand wells in Montgomery County, Kansas indicated no noticeable effect of intermittent flowing. However, producing wells with large water-oil ratios were controlled or shut in. When a high water-oil ratio well is shut in, it should be tested periodically and produced again if oil production increases and water declines.

QUESTION: It is reported that on some pattern water-flooding projects which have apparently reached the end of their economic life, with good results, the injection wells have been plugged and alternate producing wells have been converted to water injection wells to effect a cross-flooding. What results have been obtained by this practice?

STEKOLL: This was done a few weeks ago on our flood near Chanute and one or two areas showed good results. One-half of the producing wells were converted to injection and lease oil production was increased. Other operators have said they had no increased production and the method was not tried extensively. Sometimes injection wells are converted to producers when back flowing yields oil.

EARLOUGHER: The experience of operators in the Nowata area shows that fair to good results were obtained from cross-flooding when the property was pumped from the start and then later converted to flowing, but there was no comparable response from cross-flooding leases which had been flowed from the start.

ANDRESEN: Many operators in the Bradford field in Pennsylvania have cross-flooded their properties and potential reserves have been increased by 50 million barrels. Many properties in this area are now undergoing a third flood, where the completion practice was poor on the original flood and where completion practices were improved for the second flood, and finally cross-flooded.

Selective Plugging

QUESTION: Discuss selective plugging, how is it done? How effective has it been?

PYLE: Before plugging the maximum injection pressure is maintained on the wells. The plugging medium is then introduced at the surface and the well is shut in. Back flow from the tighter zones carries the material into the loose zones plugging them off.

ANDRESEN: Whenever a well takes an abnormal amount of water several matters should be considered. It may be due to peculiar geological conditions or to faulty completion practices. The injectivity index should be checked to determine if the well is taking too much water because of too high a pressure. Where the difficulty is due to differences in permeability, the well may be selectively plugged with an emulsified solid. In the Bradford area this has been successful in nine out of ten cases.

QUESTION: How is the best way to plug off bottom-hole water in water-flood producers?

PATE: We have had no experience with bottom-hole water. Where a shale in an injection well took an abnormal amount of water the well was backflowed

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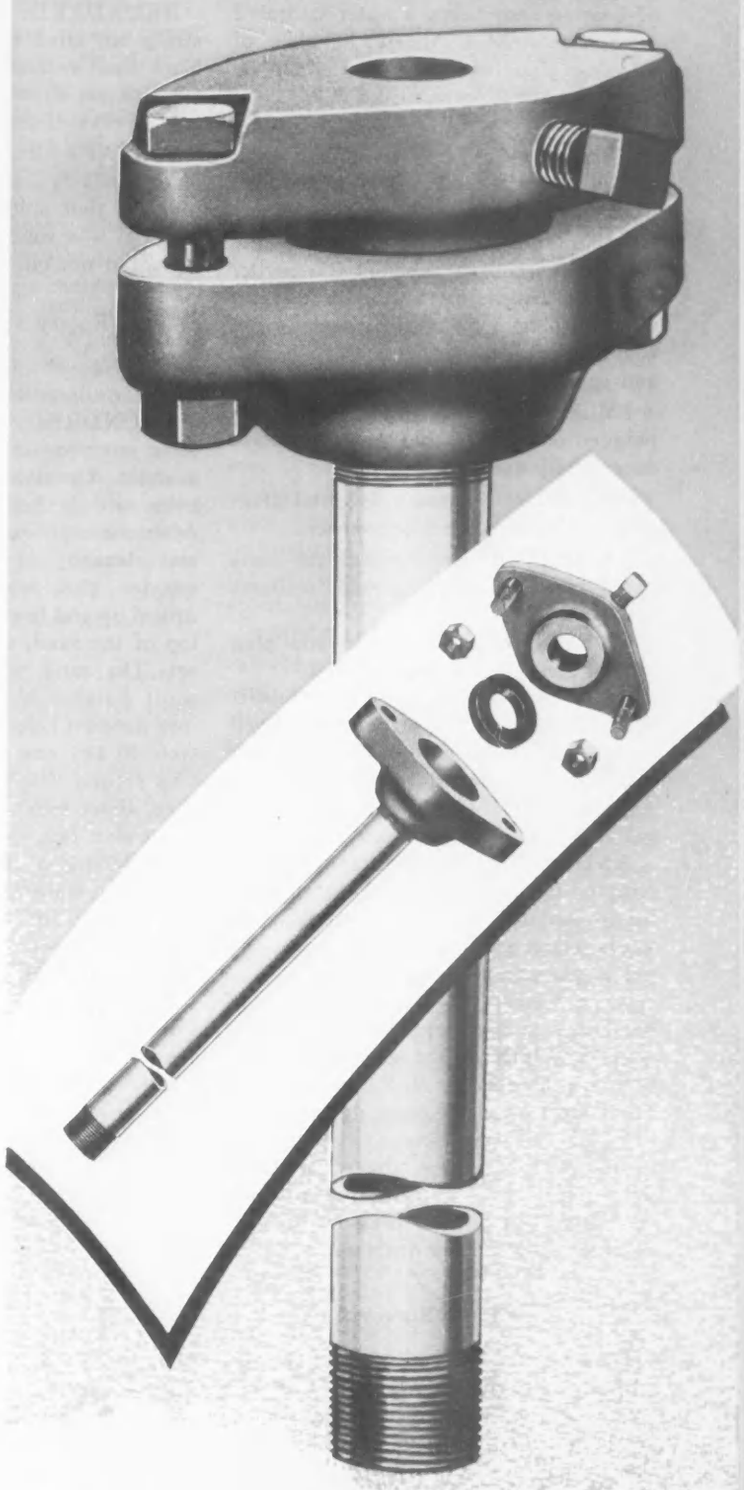

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until quiet and then plugged back with cement. Gel control additives and cement have been used with success.

ANDRESEN: Where there was an oil-bearing zone below a water-saturated zone the problem would be that of selective plugging and resins would be most successful.

BRUNDRED: In our property a porous limestone under a sand was successfully plugged off with cement, lead wool and then cement above.

EARLOUGHER: Where bottom-hole water is present. Perhaps one-third of all wells are drilled into bottom-hole water in developing a property. Plastic is the best method of plugging, lead wool next, and cement the least effective.

PYLE: In the few cases we have plugged off bottom-hole water, we have successfully used cement.

QUESTION: Discuss the total plugging of highly permeable zones.

ANDRESEN: This is done the same as in selective plugging with resinous material.

QUESTION: How would you plug such a zone in a producing well?

ANDRESEN: Generally it is unsuccessful to try to plug a producing well since the material washes back out, but it may be done in some flowing wells.

QUESTION: Discuss the use of silica gel for plugging.

ANDRESEN: This has been attempted in three wells and was successful in sealing off well-defined separate sands which are not oil productive. The gel is placed in the same manner as a squeeze cement job. It sets up in six to ten hours in the formation.

QUESTION: What success has been had with fibertex, ground lime, or other mechanical means of plugging fractures?

PATE: In one of our wells there was a fractured limestone above the sand. Pulverized lime was mixed and pumped in under 7000 pounds pressure to successfully plug off the fracture.

Spinner Surveys

QUESTION: Describe useful results of spinner surveys on intake wells.

EARLOUGHER: Where the hole is of regular size and unshot a spinner survey is useful. In one well the survey showed that a black sand and black shale at the base of the producing sand section was taking 50 percent of the injected water. Different injection pressures show substantial differences in the intake rates of the sands. Where the spinner survey shows water going into the entire section of unproductive black sand, this sand should be considered a thief zone, and shut off. The lowest measurable injection rate with a six-inch spinner in a six-inch hole is 300 barrels per day, but where a four-inch spinner is used with an umbrella in a six-inch hole, rates as low as 150 barrels per day can be measured.

BRUNDRED: In the Paola shoestring we tried to force water into a black sand section without results. Core examination showed these sands to contain streaks of coal.

TALIAFERRO: Examination of the black sands by Bureau of Mines chemists revealed that much of the hydrocarbon material was solid or semi-solid asphaltines and not oil.

Rotary vs. Cable Tool

QUESTION: Compare the results of rotary drilling with cable-tool drilling.

BRUNDRED: We used rotary to clean out two old holes which had been abandoned in 1932. We located the old holes with a bulldozer and moved in. After some difficulty with mud the hole was cleaned out to 360 feet where a wooden plug was located. This was drilled up and the hole cleaned out to the top of the sand, where casing had been set. The sand was reamed out for a short distance and then the bit dropped into the shot hole. Cleaning out time was from 10 a.m. one day to 5 p.m. the next. The second hole took somewhat longer time, above two days. When an old hole is cleaned out, casing is set above the sand, tubing is set in chat with packer above and cemented.

QUESTION: Compare rotary and cable-tool cores.

EARLOUGHER: In a comparison between comparable cores on the same lease cable-tool cores showed 1 to 7 percent less oil saturation and 8 percent higher water saturation than rotary cores. Flood-pot tests showed 8 percent less recovery in term of total pore space. Cores taken with the electrodrill showed 6 to 13 percent higher oil saturation than those taken with cable tools, water saturation was 10 to 15 percent less, and about 10 percent less than with rotary. Electrodrill cores taken with oil or with water as the drilling fluid showed the same water saturations. Likewise preliminary reports of deep well coring show the same water saturation with both drilling fluids.

PYLE: In drilling wells to flood the Patoka field in Illinois, wells were drilled to the sand with rotary and cored with cable tools, because it was found that rotary cores were badly flushed, whereas cable-tool cores were not.

QUESTION: Assuming that the water content of a sand can be definitely determined, what is the maximum water saturation that can exist naturally in a sand formation and still not disastrously influence the results of water-flooding?

PYLE: In general the more water content the less oil content of the sand, and there must be enough oil in the sand to be flooded economically. There are instances of successful floods where the sand was saturated with 50 percent water but these are probably near maximum.

STEKOLL: The methods of determining water saturation may be the deciding factor but in general water saturations of 50 percent in a dirty sand, and 40 percent in a clean sand are upper limits.

TALIAFERRO: In North Texas, sands producing equal quantities of oil and water have been flooded successfully.

QUESTION: How can water content of reservoir rock be determined accurately from cores?

PYLE: If cores are taken with oil-base mud it is assumed that the water content of cores is no higher than that of the reservoir rock. Tracer studies have been made using dextrose to determine the amount of drill water which has entered the core. These studies assume that no formation water has been flushed out by drilling fluid.

A. P. CLARK, JR.: In chip coring, ten pounds of dextrose is mixed with one barrel of water to give accurate measurements of the amount of drill water which has entered the chip cores.

ANDRESEN: The restored state method, which assumes to simulate original conditions of water displacement by accumulating oil, has given water saturation values comparable to those measured on cores taken with oil-base mud.

PATE: On a lease in northeastern Oklahoma most of the water in the sand was not connate water but water which had migrated into it from other sources. In water flooding stripper fields the important question is not how much water the sand originally contained but how much it contains at the initiation of water flooding.

EARLOUGHER: No one method may be assumed to give all the answers; oil-base mud may flush water from the sands. If all coring methods indicate about the same water saturation and these check calculations by the electric logs, this value may be assumed to be approximately correct. If measurements do not agree it may be necessary to guess which is most nearly correct.

Injection Rates

QUESTION: What is the optimum injection rate at the beginning of a flood, assuming that quite a range of injection rates can be had without exceeding the pressure required to lift the over-burden?

WILEY: This must be determined during the life of the flood. After producing wells have responded to the

flood, injection rates should be varied up and down and a rate selected which will yield greatest production.

PYLE: The best method may be to start with low injection rates, about four to five barrels per day per foot of sand, increasing to ten or 12 barrels per foot.

EARLOUGHER: Each injection rate must be determined on its own merits; depending upon spacing, low rates with 330-foot spacing, higher for wider spacing, and upon oil saturation of the cores. Where oil saturation is low the injection rates should be low to prevent high injected water-produced oil ratios.

QUESTION: What are some of the advantages of salt water as a flooding medium?

PATE: Often salt water results in less swelling of the cementing material permitting more water to be injected at a given pressure. Usually the character of salt water does not vary and treatment can be constant, whereas the character and required treatment of fresh water may vary with the seasons.

QUESTION: Has the use of closed water systems been satisfactory?

PATE: There have been some failures in closed systems where the injected water contained hydrogen sulfide and the connate water contained iron. In some cases meters have been stopped by precipitation of lime and it is possible that some lime may be precipitated on the sand face. In Greenwood County, Kansas, the Big Salt sand water has been successfully injected into the Bartlesville sand.

QUESTION: Has the deaeration of injection water by chemicals and by vacuum towers been successful? Discuss the equipment and chemicals used.

BRUNDRED: In our operations in the Paola shoestring, vacuum is applied after aeration of the Arbuckle limestone water. In the winter the water contains about ten parts per million of oxygen before aeration, and after applying 27 inches of vacuum it is reduced to about 1.2 ppm. In the summer water contains about five ppm and after vacuum treatment this is reduced to about 0.4 ppm. As yet no satisfactory chemical method to remove the last traces of oxygen has been found. Sodium sulfide was tried but it reacted with calcium carbonate to form calcium sulfide which deposited on lines and meters. Treatment was discontinued for fear the deposits might form on, and plug the sand face. A new tower 30 inches in diameter and 40 feet high with 32 feet of ceramic rings is being constructed. It is calculated that 28 inches of vacuum will reduce the oxygen content of the water below the results which have been obtained with the present equipment. To prevent reaction of oxygen with pipe, all pipe and tubing is plastic coated. Current-breaking nipples are installed in the injection lines to prevent corrosion by electrolysis.

QUESTION: Discuss experiences with liquid and solidified shots.

WILEY: We have had no experience with anything but nitroglycerin because we felt that there would be no benefits to be derived from using the solidified. Generally the solidified has less cracking effect and requires more clean-out time. If the well is worth shooting at all, it is worth shooting with nitroglycerin.

ROBERT BOSSLER: Some time ago we made tests on nine similar wells, three central wells were shot with nitro whereas the six outside wells were shot with solidified. There was no marked difference in clean-out time and after periods of 100 days, 1 year and 2 years, no appreciable difference in intake rates could be noted. Consequently, because of difference in initial cost and because of safety in handling, we now use solidified exclusively.

ANDRESEN: In Bradford, liquid nitroglycerin has been found superior to solidified.

PYLE: Originally we used nitroglycerin and after trying solidified we went back to nitroglycerin.

STEKOLL: In Texas where the producing sand is a dolomite, solidified has shown best results. In one area in Kansas the injection wells show no effect of shooting but production of 20 shot wells is double that of 20 unshot wells. In another area both injection and producing wells were helped with nitroglycerin shots but in neither case was there any increase in water-oil ratios.

Highest Viscosity

QUESTION: What is the highest viscosity oil that has been successfully water flooded?

PATE: Fair results have been obtained by flooding a 500 millidarcys sand containing 21.8 API oil with a viscosity of 248 centipoises at 67 degrees F., reservoir temperature. Evidence seems to indicate that no upper limit can be fixed for viscosity alone.

PYLE: Many California fields with high viscosity oils are subject to natural water drive and consequently should be water flooded satisfactorily.

QUESTION: What results can be expected from intermittent flowing of producers and what schedule is followed?

PYLE: Tests in Bradford indicate no difference between production at steady and intermittent rates, but in Oklahoma better results have been obtained by intermittent flowing.

QUESTION: Is there any difference between the break-through or critical pressures for 2.5 acre five spot, and ten-acre five spots?

ANDRESEN: Generally, break-through occurs when the sand face pressure is about one pound per foot of depth. This is the calculated pressure required to lift the overburden but more often the phenomenon is an actual vertical fracture of the sand and the pressure does not depend upon the spacing of the wells.

Flood Bank Control

QUESTION: What means of controling direction of flood bank is most successful where input producers pattern is irregular?

BRUNDRED: Originally we plugged out many wells which did not fit the pattern but later we came to realize that a hole in the ground was valuable whereever it was located and should be used as long as it would produce oil. Unless there is difficulty with casing they should be produced and used for injection when the water-oil ratio becomes too high for profitable operation.

STEKOLL: We did plug out some valuable wells which we now use. Actual control of the oil bank in the sand is difficult since water follows streaks of high permeability and low pressure.

QUESTION: Under what conditions can old wells be used successfully as water-input wells?

EARLOUGHER: If the sand is good from top to bottom, the well can be used successfully. Where there is a gas sand above and a water sand below, the packer should be set below the gas sand and the water sand should be cemented off. Where the sand has been completely fractured by shooting, it is best to drill a new well.

BRUNDRED: We discovered oil leaking upward from an unknown abandoned hole under our plant, so we cleaned it out to 370 feet and cemented in tubing and we now have a six-barrel a day well in the middle of the plant area.

QUESTION: What success has been had with meters for measuring oil into pipe lines?

STEKOLL: Positive displacement meters are being used where the well produces clean oil, that is no sand or paraffin. These have a separator for removing gas before metering and a continuous sample of the metered fluid is taken out, one drop per barrel, or one drop per gallon. The percentages of oil and water in the metered fluid are calculated from the composition of the removed sample. These meters are gradually coming into greater use and their accuracy is calculated to be about 0.2 percent.

How to do it! PRODUCTION HINTS

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HOW TO—Fasten and Lock Cattle Guard With Sliding Rails

Where cattle guards replace the swinging gate, it is impossible to lock them during the time when no lease man is on duty. A simple method which allows sliding pieces of one-inch pipe to be fastened and locked is shown.

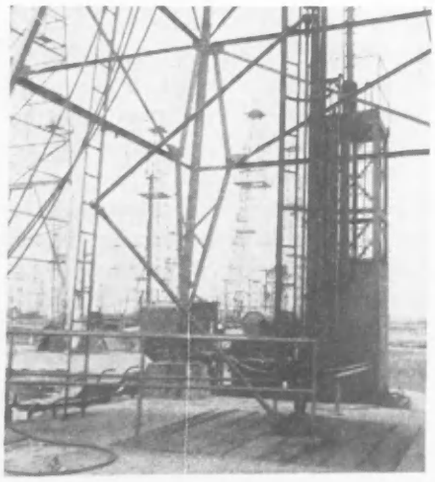
After the cattle guard is erected, four two-inch nipples are welded to the sides of the cattle guard, parallel to the ground. Four joints of one-inch pipe are then thrust through the two-inch pieces and a section of one-inch pipe is welded across the outer ends. Two longer pieces of one-inch are then welded to the inside ends so that the lower ends rest in a well which has been welded to the center of the cattle guard.

A lock and hasp is tack welded to the tops of the pipe so that when they are brought together, the hasp can be turned down over the steeple and the lock inserted. This device is a simple means of preventing unauthorized entry on a lease.

HOW TO—Rig Flexible Lead Line Coupling

On wells which are pumped with a macaroni string instead of sucker rods, well fluid generally is conducted to the lead line through a short length of flexible rubber or composition hose. This is satisfactory on conventional short stroke pumping units, but on the long stroke, hydraulically pumped wells, the use of a flexible hose is not so practical. One operator solved the problem in a simple, inexpensive manner by joining two lengths of two-inch pipe with a ball-bearing swivel type joint, then assembling the unit between the upper end of the macaroni string and the lead line. A common union installed at each end facilitates the attaching and removal of the unit when the well is to be pulled or otherwise worked on.

The flexible lead line coupling, in following through the complete cycle, does not touch the derrick floor and moves comparatively slowly, but to protect workmen or passersby from possible injury when the unit is coming down on the stroke, a narrow, all-enclosed guard rail made of salvaged piping is set up across the floor.



HOW TO—Insure Pressure Relief

Burst plates on separators are a good protection from explosions, but where a slight relief is necessary at times in gas-lift operations, a spring operated relief valve can be used advantageously. By mounting the burst plate in a flange on top of the separator, and taking off with a connection for the relief valve, both purposes will be solved.

The relief valve is set at the working pressure of the separator, and the burst plate is designed to fracture at a pressure approximately 50 pounds higher. During the rare times that the separator reaches the working pressure, the spring loaded relief valve will pop, but if it has become corroded or stuck, the burst plate is always present to safeguard the separator from excessive pressure.

Instead of mounting the burst plate on the top flange of the separator, a short nipple is added, and the burst plate bolted to the end of this riser. A short section of 1½-inch pipe is welded to the riser and connected to the pressure relief valve.

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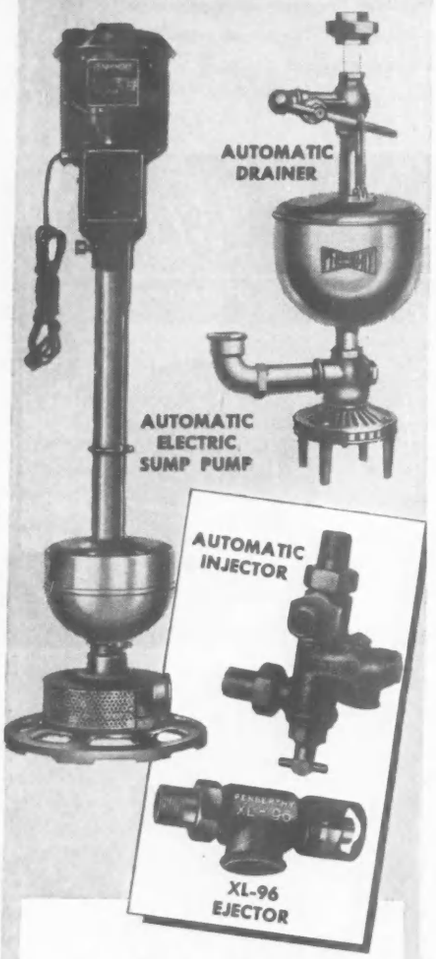

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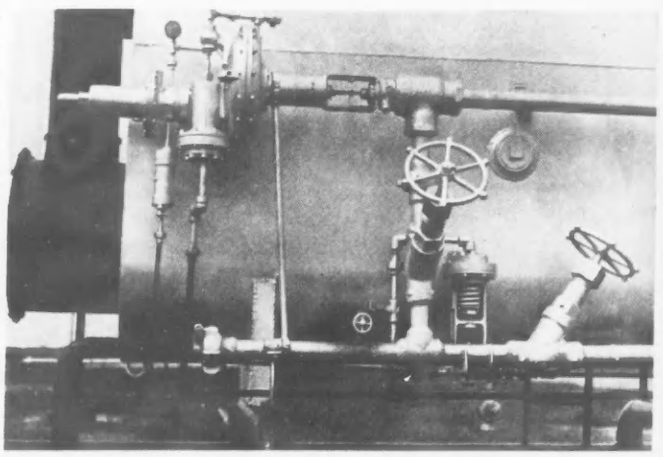
HOW TO—Build Self-Bracing Corner Posts

A type of corner post that has exceptional strength to withstand the rough treatment frequently imposed upon it, yet which can be built at little expense and is easily installed, is illustrated. It is made of salvaged two-inch tubing or line pipe, and has as its principal feature the provision of being self-braced by the additional or second leg, which at the same time gives structural support to the post. Since most of the strain imposed by tightening of the turnbuckle-equipped sand lines making up the enclosure is taken up by the bracing leg, there is little need for a broad or heavy base on the post. The base consists merely of a two-foot segment of casing cut from salvaged pipe, and welded open side down, to the bottom of the post. Two holes burned through this piece allow the unit to be set down over and secured by two derrick leg anchor belts.

Because of their small cost and exceptionally rugged construction, together with the ability to use as the fencing material used sand line which ordinarily is junked, such corner posts may be made in quantity for all wells on the lease.

HOW TO—Mount Regulators on Gas Heater



A degree of unitization as well as considerable savings in hydraulic piping can be accomplished by mounting all the pressure regulating equipment on the same skid unit as that on which the indirect gas-fired, gas heater is mounted. Such an installation served a dual purpose. Not only was there a saving in piping, but by mounting the pressure regulating equipment near the heater, the valve received some of the heat radiated from the heater shell.

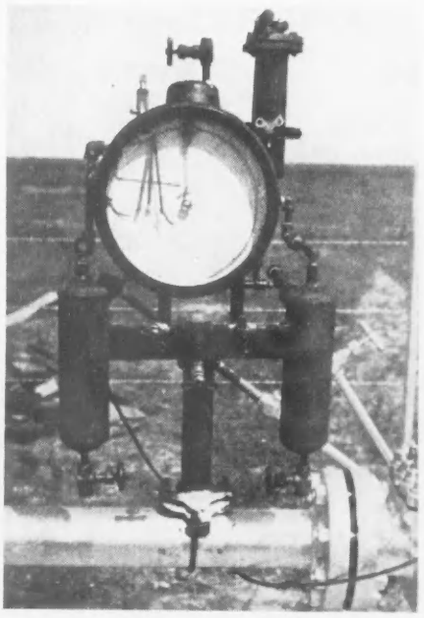
In the particular case illustrated, field gas at high pressures was heated to such a temperature to prohibit freezing of hydrates in the gas when the pressure was reduced to more than half its original line pressure. Gas entered the heater on the high-pressure side and its temperature elevated. It then passed through the regulating valve, shown mounted horizontally, and then flowed into the field gas system. To eliminate a riser, tees and nipples, the regulator was mounted as shown, being supported near the diaphragm by a vertical piece of pipe.

Auxiliary control equipment was also located near the regulator. Means is provided to close the regulator if the field line pressure should drop sud-

denly due to a line break. All piping and associated equipment is supported on four-inch pipe which is made into a framework on which the entire heater is mounted. When it is desired to move the heater, all components of the unit can be moved by merely breaking the gas inlet and outlet connections. Considerable time is saved, and since the high-pressure fittings are welded together, it is not necessary to cut out these fittings when moving the heating unit.

HOW TO—
Control Separator

After a gas condensate well is brought in and laboratory analysis shows the proper temperature and pressure to carry on the separator to obtain the maximum recovery of liquids under retrograde condensation, it is necessary that the fluctuations be held to a minimum. In order to determine just how



close the temperature controller is holding the separator temperature, a third pen on the orifice meter recorder is installed. This pen is usually calibrated to the static pressure scale so that the removal of one digit will give the temperature, that is, 1500 pound line is 150° F. By knowing exactly the gas temperature as well as the pressure the separator conditions may be adjusted to give maximum recovery, and a check is made that the temperature is maintained at the desired figure. Of course the temperature record gives an additional control in figuring the temperature factor in measuring the volume of gas passing through the separator.

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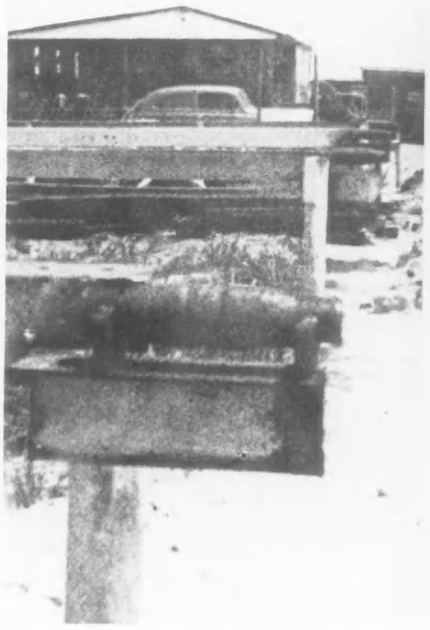
HOW TO—Facilitate Pipe Handling on Plant Storage Racks

Pipe racks are usually placed in rows parallel to the plant drive. If it is necessary to move pipe from one rack to another, a truck is employed unless a method is devised for moving the pipe lengthwise manually.

One method for doing this has been used which makes use of dollies mounted on the ends of the racks. Using split two-inch flanges for bearings, rollers are turned down from soft steel billets to fit the bearings and grooved in the middle to hold the pipe. The bearings are tack welded to the tops of two angle iron pieces which are welded to the tops of the rack posts so that the roller is slightly above the level of the top of the rack.

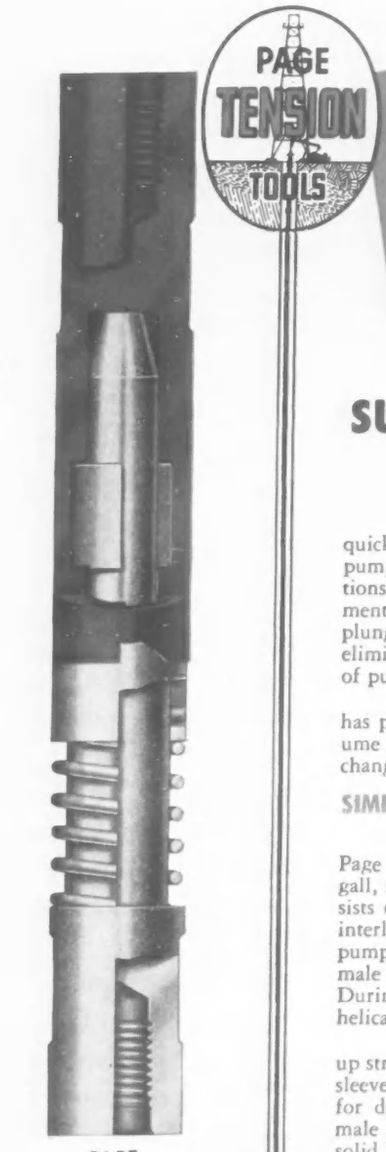


When a joint of pipe is to be transferred from one rack to the other, it is rolled up on the dollies and rolled longitudinally until it lines up with the rack for which it is intended. Another use for the dollies is to line up the pipe prior to rolling it onto a truck. The pipe can be rolled rapidly out to the dollies without taking time to aim it for the proper place on the truck, and then it can be easily lined up before rolling on the truck.

HOW TO—Dispense Chemicals

A simple, efficient method for transferring chemical for treating crude emulsions may be rigged up without the use of valves. An ell and 24-inch nipple fitted with a cap serve as the dispensing equipment. These are screwed to the drum before the drum is placed on the rack. The cap is allowed to remain "handy" on the ¾-inch pipe nipple with the outer end of the pipe placed at a point higher than the liquid level in the drum.

Whenever it is necessary to fill the container in the chemical pump, the cap is removed and the end of the pipe lowered so that the liquid will run into the



PAGE
ON & OFF
ATTACHMENT

Easy engagement
Easy release
A RUGGED
Rod-to-Plunger Connection

THAT'S THE PAGE
SUCKER ROD ON and OFF ATTACHMENT

The Page On & Off Attachment provides a quick, effective means of joining sucker rods to the pump plunger in tubing and casing pump installations. Its proven design permits removal and replacement of sucker rods without disturbing the pump plunger—a foolproof clutch-type locking mechanism eliminates chance for failure even under the severest of pumping conditions.

The success of the Page On & Off Attachment has prompted many operators to switch to larger volume pumps. The result—immediate payout for the changeover through increased production.

SIMPLE CONSTRUCTION—SIMPLE OPERATION!

Simplicity of construction is the keynote of the Page On & Off Attachment. There are no threads to gall, no complex mechanism to foul up. The tool consists of a male and female section which interfit and interlock when the sucker rods are lowered onto the pump plunger. A ¼ turn left rotates shoulders on the male section into milled out slots in the female section. During rotation a locking clutch engages by force of a helical spring positioned below it.

Disengagement of the tool requires only slight up strain and a ¼ turn right. This forces the clutching sleeve down and permits rotation of the female section for disengagement from the male section. Both the male and female sections are milled and turned from solid billits of steel and are held to close tolerances to virtually eliminate chance for wear.

Tear out this page—enclose it in an envelope and mail to Page Oil Tools, Inc., Long Beach, California, for further details.

Mid-Continent Distributors
D+B Division—Emsco Derrick & Equipment Co.,
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container. The two-inch plug is loosened slightly to permit air to enter drum as the liquid is removed. The cap over the end of the pipe prevents dust from blowing into the end of the line, and yet the piping is always at hand to fill the chemical container.

HOW TO—
Make Field Gas Heater

Freezing at the regulator on high-pressure gas lines can be eliminated, or considerably reduced by elevating the gas temperature before it undergoes a pressure drop across the regulating valve. Such steps were necessary in handling field gas taken from a high-pressure separator and used for field and camp use. The separator operating pressure, approximately 1000 pounds per square inch, was lowered to less than half that pressure by regulating valves. This lower pressure was used in the main field supply line and was again lowered to pressures required by the pieces of equipment requiring gas.

A water-emersed coil heater was fabricated in the shops to handle this particular problem. Gas coming from the separator entered the heater on the right through a drip designed to remove as much of the hydrates as possible. After passing through some two or three hundred feet of coiled pipe, the gas was

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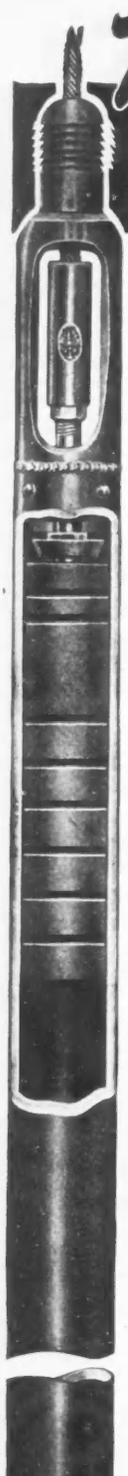

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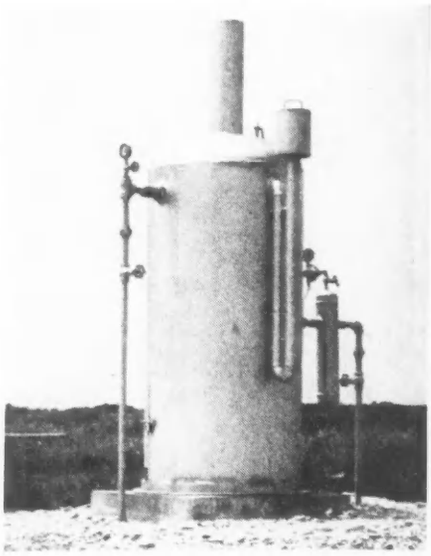
PRODUCTION HINTS

passed into the field gas system.

The compacted pipe coils were suspended inside a circular container filled with water. The container was fitted with a "water leg," shown at right, attached to the heater, to reduce evaporation of the heater water and, in case the thermostat failed, the water did not boil and blow up the unit. Instead, the steam formed would exhaust through the "water leg."

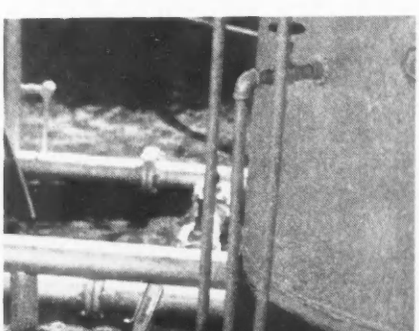
Field gas, reduced to a few pounds pressure, was used to fire the heater. Burners were placed below the water container in circular fashion to obtain even heat distribution through the water element. The water container was enclosed in a shell that provided several inches annulus thereby permitting the flue gases to escape through the stack.



HOW TO—Group Separator Lines on Bracket

To stop vibration and remove possibility of breakage of fittings on test cock lines on the side of a production separator, one company finds it convenient and inexpensive to anchor the lower ends of the lines to a T-shaped fitting welded to the side of the trap. The support, made of salvaged sucker rod material, is welded to the skirt some 12 to 15 inches above ground level.

Three evenly spaced rings are welded to the bar, the outlet lines being run through the loops as shown. Anchored in this manner, the lines are less susceptible to damage from accidental bumping, and because they are grouped in one spot, a common drip collecting pan can be placed under the outlets. The welded bracket does not prevent the salvage and removal of the pipe fittings.



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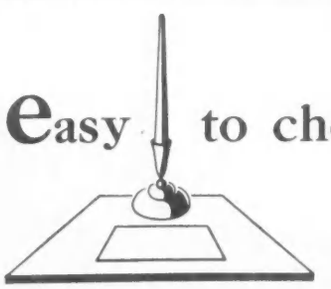

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Pressure Surges and Vibration

In Reciprocating Pump Piping

By J. W. SQUIRE,
Stanolind Pipe Line Company, Tulsa

INTRODUCTION of multicylinder, high speed, short stroke pumps for pipeline service has necessitated a complete revision of the earlier methods for suppressing vibration and pressure surges. The author develops means for attaining satisfactory operating characteristics, and provides formulae for determining conditions of resonance. The paper was originally presented, in somewhat more extended form, before the Petroleum Mechanical Engineering Conference of the ASME at Amarillo, Texas.

SURGES in the lines because of fluctuations of pressure at and near the prime movers have always plagued the operator. In 1903 Professor Goodman[1] recognized some of these problems. "In the early days, the long lines gave constant trouble owing to frequent bursts, although the pipes had a large margin of safety over any static pressures to which they were likely to be subjected. When precautions are not taken to prevent sudden changes of velocity in the pipes and passages of fast-running pumps, very serious 'shock' pressures may be set up even with short lengths of pipe."

Most of the early crude oil pumps used were direct-acting, operated by steam. The steam cylinder cushioned the shock somewhat, and few breakages were experienced. The next step was using a steam crank with a light flywheel directly connected to the pump. The steam end still cushioned the shock effects of the pressure surges. The widespread use of the slow-speed diesel engine using heavier flywheels and a gear-reduction system to the pump in the early 1920's served notice to the pipe line industry that further consideration of the surge problem was necessary. What had been manifesting itself in "short stroking" in the steam-operated units now began to appear as numerous and widespread breakages of the lines. When the lines and line fittings were "beefed-up," the pumps broke. When the pumps were strengthened, the lines broke. It was not until about 1924, therefore, that the seriousness of the problem became apparent. There were then some 40,000 miles of pipe lines in the U. S. carrying crude.

Breakage Study

At this time W. D. Pomeroy, vice-president and general manager of Goulds Manufacturing Company; Professor H. Diederichs, director of the Sibley School of Mechanical Engineering, Cornell University; and others instituted a study of the causes of these breakages. Their research was concerned primarily with an attempt to adapt the use of air and vacuum chambers or alleviators on the suction and discharge sides of the pumps to cushion the shock of the pressure waves set up by the pump in the piping systems in use. In so doing, a study was made of the effects of the piping system design on these pressure waves. This work was carried on both at the Goulds factory in Seneca Falls, N. Y., where it was feasible to study test units under controlled conditions, and in the field under actual operating conditions at several pipeline stations. A preliminary paper outlining the results was presented in February, 1926, by N. B. Delevan.[2] Their main results and specific conclusions[3] are summarized as follows:

1. If the piping design is such that a reflecting point, such as a sudden enlargement or contraction of the line, carries back pressure waves which are in synchronism with those of later waves of pressure produced by the pump plungers, very high pressures are developed; and failures of the line or pump parts may result. This phenomenon has long been known as water hammer, and many studies have been made of it. Field conditions were found where pressure swings of 310 to 1030 pounds per square inch on a 675-pound line were typically present. When these conditions exist to such an extent that the liquid column breaks, they are even more serious.

2. The pressure impulses travel at the speed of the sound in the liquid, being modified by the gravity of the liquid and the size of the pipe.

$$C = \sqrt{\frac{gJ}{m}}$$ where

C = Velocity of pressure wave in the system (ft./second).
g = 32.2 ft./second/second.
m = Density of the liquid (lbs./cubic ft.).
J = Virtual modulus of elasticity of the liquid and pipe. (See appendix.)

Average figures of C for oil are around

TABLE 1
Fundamental Volumetric Variation of Typical Pumps.

TYPE	RPM	PERCENT VOLUMETRIC VARIATION			Cycles/ Rev.	Cycles/ Second	Reference
		Above Mean	Below Mean	Total			
Horisontal Double-Acting Duplex	36	24.1	21.5	45.6	4	2.4	Fig. 1
Horisontal Double-Acting Duplex	58	24.1	21.5	45.6	4	3.9	Fig. 1
Horisontal Double-Acting Triplex	36	6.1	16.8	22.9	6	3.6	Fig. 2
Horisontal Double-Acting Triplex	73	6.1	16.8	22.9	6	7.3	Fig. 2
Vertical Quintuplex	175	1.8	5.2	7.0	10	29	Fig. 3
Vertical Quintuplex	277	1.8	5.2	7.0	10	46	Fig. 3
Horisontal Twin Quintuplex	425	1.4	4.2	5.6	10	71	Fig. 4
Vertical Septuplex	225	1.2	2.8	4.0	14	52.5	Fig. 5
Vertical Septuplex	256	1.2	2.8	4.0	14	60	Fig. 5
Vertical Single-Acting Triplex	229	6.1	16.9	23.0	6	22.9	.....
Single-Acting Quadruplex	...	11.0	21.5	32.5	..	....	.....
Single-Acting Sextuplex	...	4.8	9.2	14.0	..	....	.....

4000 feet per second in six and eight-inch pipe as derived in this paper.

3. Short lengths of piping between the pumps and manifold are desirable and cause less breakage than long lines, particularly when more than one unit discharges into a common manifold. The conditions vary considerably where long lines between pumps and manifold exist; in fact, no two are the same. If there are no critical points of reflection, the primary impulses tend to die out because of friction loss in the pipe and internally in the liquid. Any actual installation, however, is seldom without discontinuities in the piping, which multiply the chances of a resonance condition in the piping system, particularly when it is considered that all odd harmonics must be taken into account.

4. The use of air chambers near the pump intelligently applied prevent dangerous surges.

The above points represent those of the authors previously mentioned and are amply and completely covered in their paper. Much information and valuable data are included in this work in particular for speeds and design of pumps up to that time. The latest units then consisted of duplex or triplex double-acting pumps powered by oil diesels and using positive gear-reduction drives.

Surge Chambers

Surge chambers were used with some effectiveness; but the ever-present possibility of an explosion, the extra cost of installation, and the cost and inconvenience of maintenance were disadvantages to be considered. The construction of additional larger units at all main line stations with all pumps working into a common manifold resulted in numerous piping failures. In order to attack this problem further, J. B. Harshman, Stanolind Pipe Line Company, made an investigation for the purpose of devising a simpler and more economical means for reducing pressure resonance conditions in multiunit installations. The results of his work were summarized in a paper in 1939.[4] The method consisted of connecting an equalizer line to each discharge line of the pumps. This was placed a short distance from the pump discharge headers just outside the building. Practical tests in the field showed a 1350-pound pressure swing on a single unit in a four-unit station with three units discharging at 725 pounds per square inch line pressure and connected without the equalizer line. The insertion of the equalizer line under otherwise the same operating conditions reduced this pressure swing to 120 pounds—a 91 percent reduction. Several other tests gave similar results. On two to four (or more) unit stations, this means for reduring pressure surges or fluctuations has been effectively used in numerous installations since this time.

Recently, however, several other factors have appeared which bring up new problems. One pipe line company now has a number of five and seven-cylinder vertical and twin-quintuplex horizontal pumps. These range in output from approximately 15,000 to 100,000 barrels per day, in speed from 175 to 400 revolutions per minute, in stroke from three to eight inches, and in output pressure from 900 pounds per square inch to 1500 pounds per square inch. The trend then is for higher speeds, greater capacities, higher pressures, and lighter weight in the pumping units.

The first of these, which was put into use in 1944, gave some indication of the difficulties which were to be experienced. However, there were no piping breakage difficulties on the first few installations; and the somewhat excessive noise was attributed to the speed at which the pumps were running. Some changes were made in the plungers and valve springs to reduce this noise. With the installation of larger and faster pumps of the same design in 1947, piping breakage began to appear. It was then that a series of tests was instituted with equipment which will be generally outlined later.

All of the previous work recommended the use of air chambers or equalizer lines or otherwise designing the piping to avoid these surges becoming dangerous. The nature of the surges produced in the pump cycle for the slower duplex and triplex pumps was that of large and slow variations. Now, however, the theoretical pressure variations generated by the action of the pump were small and of high frequency. Reference to Table 1 and Figures 1 through 5 demonstrates this clearly. But instead of experiencing these small pressure variations in the field, measurements were made of total pressure swings on the order of 50 to 60 percent of the mean pressure, a factor of eight or nine times the expected value. Investigations indicated that air chambers or equalizer lines could not be used effectively at these frequencies. (See appendix.)

The method of attacking the problem, then, involves primarily the concept of so arranging the flow in the pump that these pressure surges are held within a reasonable percentage of the theoretical value. Secondarily the piping should be so designed that no part of it will approach a resonance with these surges initiated in the fluid cylinders of the pump.

Stop Surge at Source

This means that instead of attacking the problem by alleviating means we are attempting to stop any dangerous surges at their source. Figure 6 shows a general layout of the pump and piping system where the conditions mentioned above were experienced. Figure 7 shows one record of the pressure surges recorded before any changes were made in the pump. This has superimposed the volumetric curve of Figure 3 converted directly in terms of pressure.

After changing the valve system design and introducing other factors, recorded results were of such low value at this point that the character of the curve was not believed recorded faithfully by our equipment. This is illustrated in Figure 8 again with the theoretical volumetric variation shown. The maximum variation of 39 pounds on the 3000-pound pressure gauge used amounted to a little more than 1 percent of its range.

What produced this marked improve-

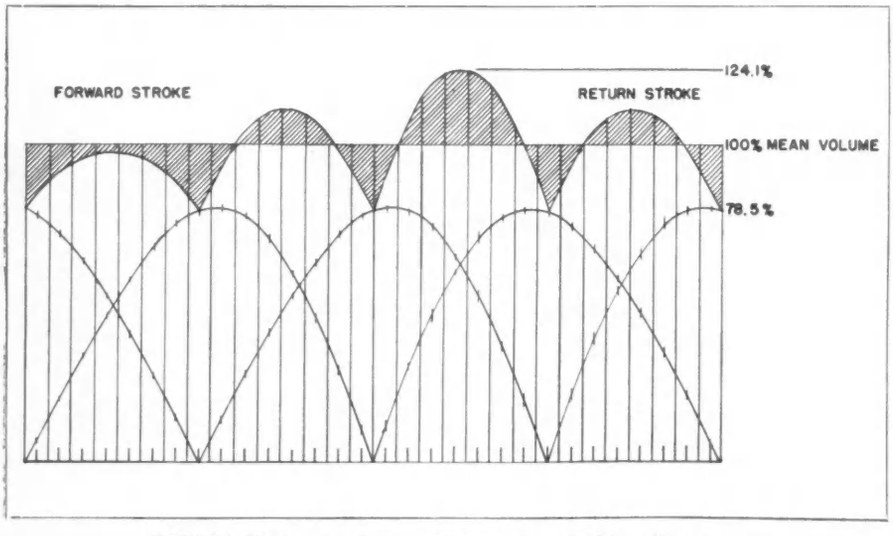

FIGURE 1. Discharge volume variation, duplex double-acting pump.

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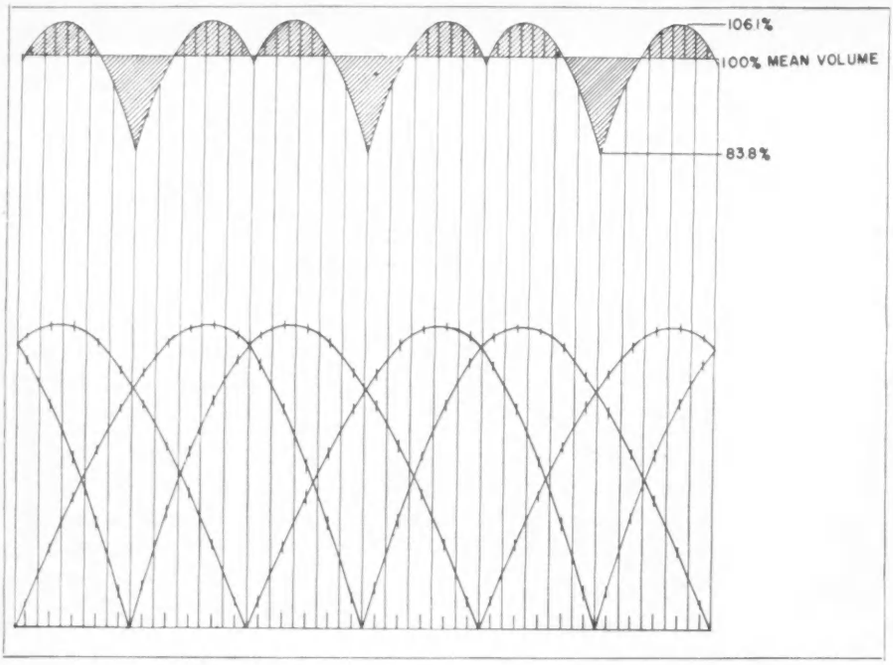

FIGURE 2. Discharge volume variation, triplex double-acting pump.

ment in operation? No changes were made in the piping. The changes in the pump are enumerated below:

1. Differently designed valves and valve seats were used in three of the five cylinders. These were such that discontinuities in the velocity of flow through the seat and across the rim of the valve were considerably reduced. At the same time, the lift of the valve was restricted to one-eighth inch in all cylinders. (No lift restriction had previously been imposed.)

2. The new valve systems had a higher natural frequency by a factor of approximately three.

3. Diameter of the plungers was changed from 7¾ to eight inches.

It is believed that the reduction of discontinuities in the velocity of flow reduced the forces likely to excite the valve system into resonance. This, coupled with the higher natural frequency of the valve system, was credited with being the main factor resulting in greatly improved operation of the pump. The valve lift reduction may also have been a contributing factor.

Scope of the Problem

THE PUMP: This leads to a consideration of the general factors in the design of high-speed multi-cylinder pumps for crude oil service.

1. The pump parts must be built to withstand greater strains, such as centrifugal forces in the crankshaft and greater bearing pressures due to increased line pressures.

2. The moving parts must be built to closer tolerances, and a good dynamic balance must be attained.

3. The design of the valves and valve seats must be such that efficiency of the movement of oil is at a maximum. Theoretically, sharp velocity changes in the flow are apt to cause valve flutter.

Also theoretically it should not be necessary to restrict valve lift beyond the maximum to produce equivalent port area in a properly designed valve. However, practical tests by several pump companies have resulted in imposing a limitation on the valve lift. This lift must be kept reasonably small to offset the inertia forces that prevent proper closure, thereby allowing quick action of the valve. Closure at the proper time means increased volumetric efficiency. Small lift also means less noise and wear on the valve plate and seat. The amount of lift on a properly designed valve should be in direct proportion to the speed of the plunger. Such a valve would be wide open when the crank is 90 degrees to the plunger and within 0.010 inch of being closed at the end of the stroke with maximum pump speed.

4. The valve system should therefore be light in weight and designed so that its natural frequency is not close to the frequency of the hydraulic forces acting upon it. This obviates fluttering.

5. The spring system on the suction and discharge valves must be designed to handle a wide variety of oils with minimum adjustment. Complex batching schedules frequently result in wide variations in back pressures and sometimes in discharge pressures. The compressed force of the springs must account for these factors as well as the weight of the valve stem and spring for optimum operating conditions. The ideal valve would have neither weight nor mass and would depend entirely upon spring pressure for closure. Since this is impossible, the mass should be kept to a minimum with ample spring pressure. In other words, the "G" factor should be kept to a minimum.

Design Factors

The design factors 3, 4, and 5 above involve many considerations on which little known data are available. A possible answer in design of future units would be the use of a system to actuate the valves by a mechanically positive means. This would obviate consideration of the many varying factors which must now be taken into account in the design of a valve system hydraulically operated.

Considerable field experimentation has been necessary to arrive at satisfactory operation of the spring system design on units now in use. These tests are by no means complete.

THE PIPING: Principles which are used in designing the pump discharge and suction piping may be summarized as follows:

1. Streamlining of flow wherever possible. Examples of this may be seen by reference to Figures 6, 9, and 10. In the

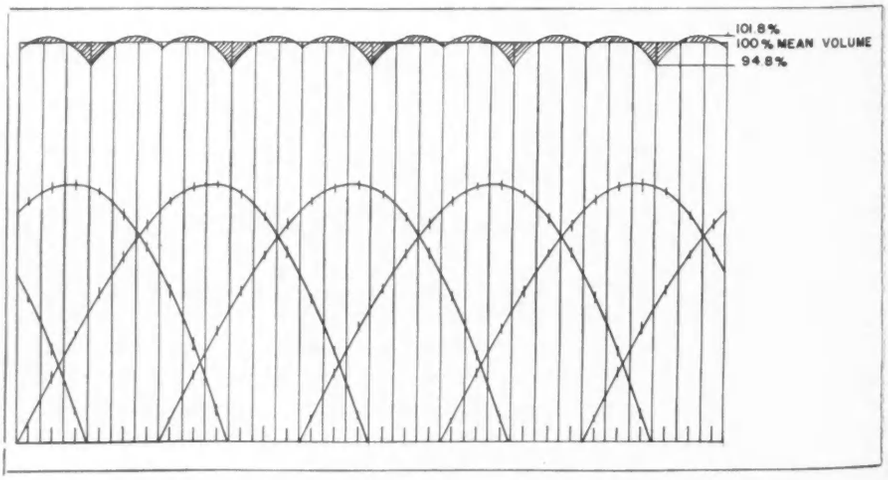

FIGURE 3. Discharge volume variation, quintuplex single-acting pump.

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piping of Figure 6, it will be noted that an attempt has been made to equalize the streams on both the suction and discharge sides of the pump to avoid unbalance in its operation. Figure 9 shows the cast discharge header construction now in use on the pump of Figure 6 and on several others on our system. Experience in the field has dictated the policy of straightening out the flow, particularly in the discharge lines. Figure 10 illustrates an example of bringing together the streams from a double-end discharge vertical septuplex pump. This pump has been operating satisfactorily at 1200 pounds per square inch discharge pressure for several months with no surge chambers. Piping vibration has been negligible. On the other hand, avoiding the use of long radius manufactured ells (1½ times nominal pipe diameter) and manufactured tees is considered impractical. The chances of reflections in synchronism with the pressure surges initiated by the pump, although possible, are believed to be negligible for two reasons. First, these fittings are very imperfect reflectors. Second, there are usually more than two points in the line between the pump and manifold where the use of one or both is necessary. These facts taken together probably mean that the resultant pressure waves are damped out to such an extent that they are not of a destructive nature. Measurements in the field have indicated this to be true, although we have been unable to calculate what is happening to any particular case.

2. Avoidance of suspended masses of piping or fittings. Small surges initiated by the pump are apt to approach the fundamental natural frequency of one of the harmonics of some section of the piping with destructive results.

Cross-Section Irregularities

3. Avoidance of irregularities in cross section, such as holes, sharp shoulders, or notches. We try to use a minimum number of saddle welds . . . never size on size with pressures above 500 pounds per square inch. Where economic or delivery reasons dictate their use rather than the purchase of a factory tee (e.g., 6 on 16 inch), they are usually rib-reinforced at the crotches. All discharge gauge connections are rated at 2000 pounds for strength.

It is also possible for mechanical vibrations to be transmitted to the piping from the pump or engine, causing dynamic stresses with which some part of the piping system is in resonance. When this occurs, breakage results. Several studies have been made of this phenomenon in the natural gas industry. This problem is related to the one covered in this paper, but we have not as yet experienced any difficulties in piping breakage attributable to this cause.

Pulsation Variation

Fundamentally, then, the discharge piping system is subjected to pulsations of much higher frequency and less magnitude than any heretofore experienced for crude oil pumping. Note in Table 1 that the pulsation variations produced by the pump vary between 2.4 and 7.3 cycles per second for horizontal duplex and triplex double-acting pumps whereas in the multiplex pumps this figure varies between 29 and 71 cycles per second. The theoretical volumetric variation per revolution on the other hand (and it may be assumed the pressure variation follows this in character on the pump discharge) varies from 45.6 to 22.9 percent for the duplex and triplex pumps respectively. The comparative variations for our multi-cylinder pumps in operation varies from 5.6 to 7 percent. This means three things:

1. The flexures of the piping system in a properly operating multiplex pump occur at a rate of from four to 30 times as fast as those of the two- and three-cylinder pumps with an average factor of about ten.

2. The amounts of the pressure surges are at the same time much smaller in the multiplex pumps than in the duplex and triplex pumps. This again is for a pump operating ideally.

3. The theoretical conditions of pressure are seldom fulfilled in actual practice. It is felt necessary, therefore, to design the piping system to handle unforeseen pressure surges at the present time.

When working into discharge pressure in the range of 1400 to 2000 pounds per square inch and handling crudes with a wide variation of viscosity (40 S.S.U. to 10,000 S.S.U. for certain cases in Wyoming), the safety factor in the discharge piping system is usually smaller, e.g., for an eight-inch discharge line designed for 1400 pounds operation using an "S" factor of 18,000 pounds per square inch (85 percent of the "S" factor in the ASA code for oil piping systems within refinery limits), the allowable pressure is 1640 pounds per square inch using extra-heavy grade "B" seamless pipe. This means, then, that the allowable working pressure should not vary over 17 percent above the mean. On the other hand in an 800-pound per square inch discharge line using eight-inch pipe, extra heavy, grade "B," seamless would again be used, giving an allowable percentage of variation of 105 percent above mean operating pressure.

The Measuring Equipment

Figure 11 shows a schematic layout of a system satisfactory for pressure and

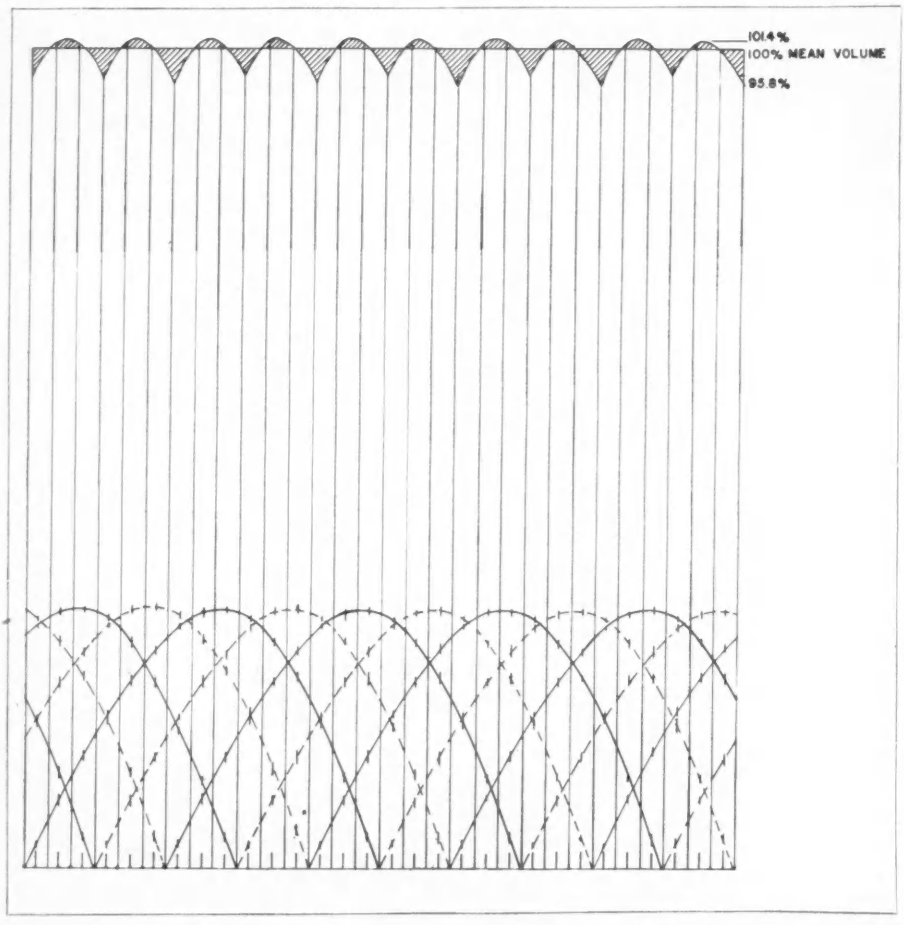

FIGURE 4. Discharge volume variation, twin quintuplex pump.

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vibration measurements in a high-speed crude oil pump and piping system.

In arriving at specifications for this equipment, several factors must be kept in mind.

First, we must have a system capable of following the pressure variations faithfully. We have arbitrarily set our standards at 0 to 1000 cycles per second.

Second, the gauge for transmitting the pressure impulses should also be as insensitive as possible to mechanical vibrations. This is one of the main difficulties which we have experienced in use of pressure gauges with an electrical output. We have as yet found no suitable gauge for fulfilling our frequency requirements and vibration insensitivity requirements.

Third, it is believed highly desirable to measure the direction and amount of mechanical vibration encountered in the piping system simultaneously with the measurement of pressure. This means using a pickup for each of three directions of motion at the measuring point. The frequency characteristics in this case have been set (again arbitrarily) at four to 500 cycles per second.

Fourth, the recording equipment should be capable of handling data from a minimum of two vibration points and four pressure points simultaneously on the same time scale. This is a total of ten channels . . . six for the two points of mechanical displacement (one for each direction of motion at each measuring point) and four for the pressure. Data should be directly readable from the record in terms of inches displacement and pounds per square inch pressure variation. A recording oscillograph or camera such as is used in seismograph work is suitable.

This type system also allows us to observe conditions quantitatively for several consecutive pump revolutions allowing such factors as hunting of the engine or beats in the data to be observed and evaluated.

The requirements of the system briefly described here have been arrived at after a series of tests conducted on one of our single-unit pumping stations in Missouri. It is believed that by proper design all of the time-consuming factors which we experienced in taking and interpreting the data can be minimized, allowing a quick and accurate determination of the pressure and vibration characteristics of any similar system.

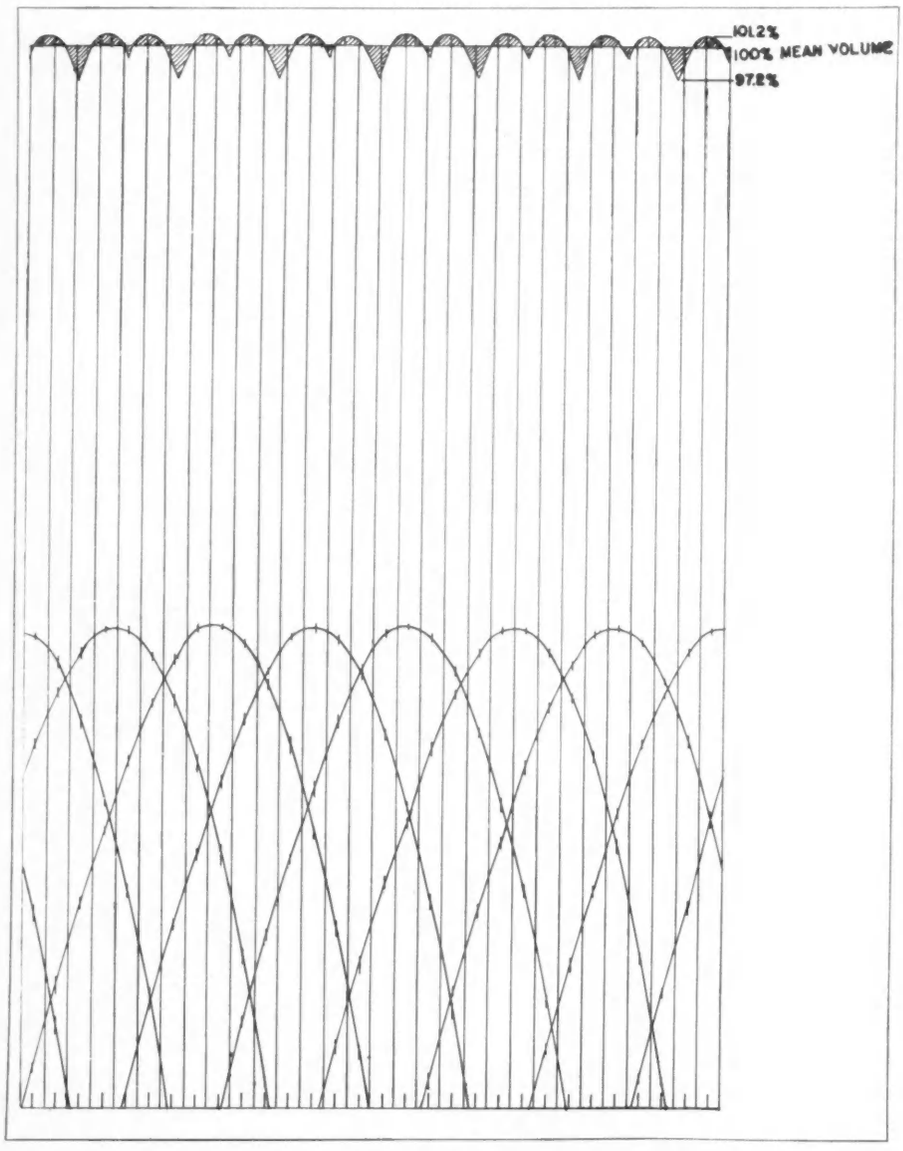

FIGURE 5. Discharge volume variation, septuplex single-acting pump.

Summary and Conclusions

For pumping crude oil at the lower pressures (up to 900 pounds per square inch), sufficient information is available for proper design of a piping system to avoid undue mechanical vibration. The design of low-speed duplex and triplex horizontal pumps is satisfactory at the lower pressures. The use of equalizer lines for two or more units on one system is a satisfactory, practical solution at lower pump speeds and pressures.

The design of high-speed, short-stroke pumps (175 rpm and greater) to handle large quantities of crude is not sufficiently worked out to avoid probability of breakage difficulties in the pump or piping. These factors become more important at the higher pressures now used.

The varying-grade crudes pumped, the use of a smaller number of large capacity pumps, and the higher design pressures encountered on a modern pipe line system complicate the proper design of a high-speed multi-cyclinder pump. Solutions to these difficulties are being worked out in actual field installations at the present time. It has not been found practical for the pump companies to set up laboratory installations for the size units used in a modern pipe line pumping station.

The higher frequencies produced by the pump as pressure surges do not unduly complicate the problem of piping design. Avoidance of sharp discontinuities in the piping system and concentrations of mass or unsupported piping sections should result in a satisfactory piping system. The use of air chambers is not justified at surge frequencies above 20 cycles per second.

Mechanical vibration transmitted from the engine or pump to the piping system is considered as a separate problem from the one covered in this paper.

Our general requirements for suitable equipment for pressure surge and vibration measurements have been fairly well established. There should be no undue difficulties in setting up such a system with the exception of locating a pressure gauge with suitable characteristics.

Several systems on the market for determining pressure variations have been studied for our use in this work. These have consisted mostly of systems designed primarily for engine character-

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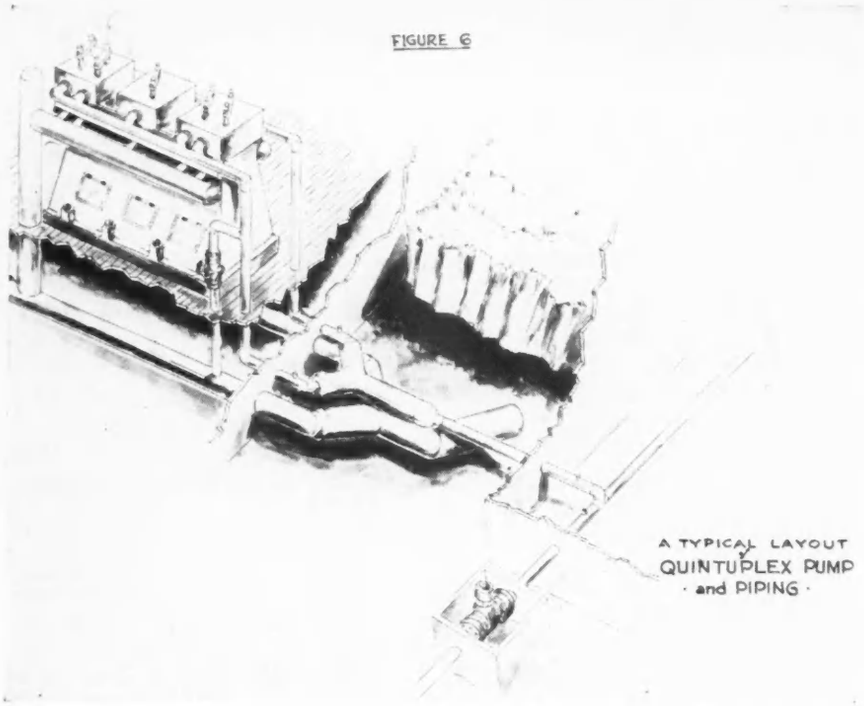

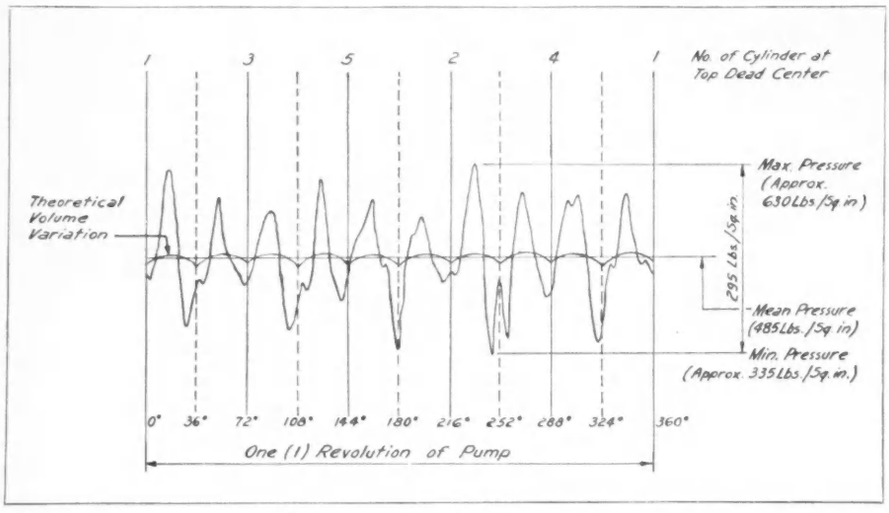
1 3 5 2 4 1
No. of Cylinder at Top Dead Center
Theoretical Volume Variation
Max. Pressure (Approx. 630 Lbs./Sq. in.)
295 Lbs./Sq. in.
Mean Pressure (485 Lbs./Sq. in.)
Min. Pressure (Approx. 335 Lbs./Sq. in.)
0° 36° 72° 108° 144° 180° 216° 252° 288° 324° 360°
One (1) Revolution of Pump

FIGURE 7. Discharge pressure variation, approximately eight feet from discharge manifold. Vertical quintuplex pump.

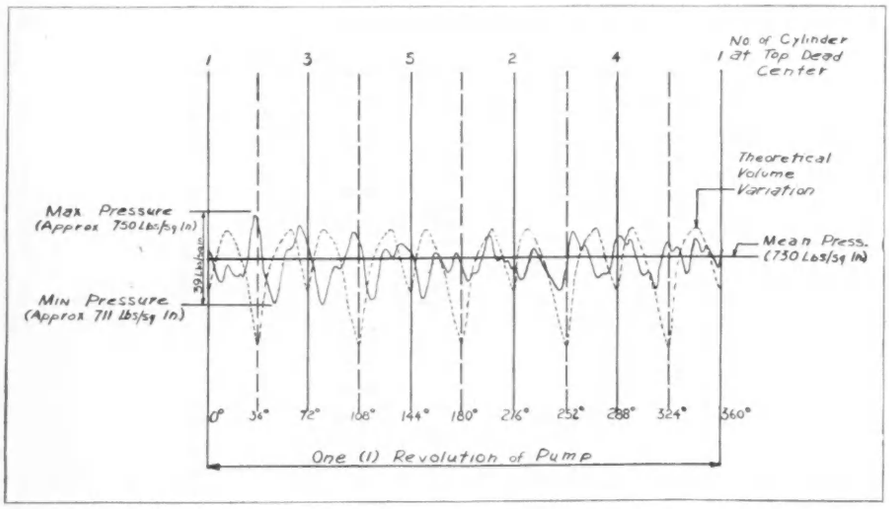
No. of Cylinder at Top Dead Center
1 3 5 2 4
Theoretical Volume Variation
Max. Pressure (Approx. 750 Lbs/Sq. In.)
Mean Press. (730 Lbs/Sq. In.)
Min. Pressure (Approx. 711 Lbs/Sq. In.)
0° 36° 72° 108° 144° 180° 216° 252° 288° 324° 360°
One (1) Revolution of Pump

FIGURE 8. Discharge pressure variation, approximately eight feet from discharge manifold. Vertical quintuplex pump.

istics measurements and are not believed suitable for our application.

Appendix

Speed of pressure wave in a pipe.

A) Symbols used.

S_u = Longitudinal stress in lbs./sq. inch.

S_v = Circumferential stress in lbs./sq. inch.

P = Pressure in lbs./sq. inch.

r = Pipe radius in inches.

t = Pipe thickness in inches.

μ = Poisson's ratio = 0.30 for steel.

$\alpha = 1/\mu = 3.33$ for steel.

x = Length of pipe in inches.

y = Circumference of pipe in inches.

e_u = Logitudinal strain.

e_v = Circumferential strain.

E = Modulus of Elasticity lbs./sq. inch (Steel = 30×10^6).

K = Bulk modulus of liquid lbs./sq. inch (37° A.P.I. oil @ 60° F. = 200,000).

V = Original volume.

ΔV_p = Change in volume of the pipe (expansion).

ΔV_L = Change in volume of the liquid (compression).

ΔV = Total relative change in volume due to expansion of pipe and compression of liquid.

Δr = Change in radius.

Δx = Change in length.

C = Speed of sound or pressure wave in the combination of liquid and pipe.

J = Effective modulus of elasticity of pipe and liquid accounting for compressibility of liquid as well as circumferential and longitudinal expansion of pipe lbs./sq. inch.

M = Mass of oil lbs./cu. ft.

g = Acceleration of gravity = 32.2 ft./sec./sec.

In the case of a pipe carrying oil, the velocity of a pressure (or sound) wave is modified by the elasticity of the oil and the steel.

For the pipe:

$$S_u = \frac{Pr}{2t}; S_v = \frac{Pr}{t} \qquad (1)^{5,6}$$

From Poisson:

$$e_u = \frac{\Delta x}{x} = \frac{S_u}{E} - \frac{S_v}{\alpha E} = \frac{Pr}{2tE}\left(1 - \frac{2}{\alpha}\right) \qquad (2)$$

$$e_v = \frac{\Delta y}{y} = \frac{\Delta r}{r} = \frac{S_v}{E} - \frac{S_u}{E} = \frac{Pr}{E}\,\frac{2-1}{2} \qquad (3)^{5,6}$$

$$\text{Since } \frac{\Delta y}{y} = \frac{\Delta(2\pi r)}{2\pi r} = \frac{\Delta r}{r}$$

$$V + \Delta V_p = (x + \Delta x)\,(r + \Delta r)\,\frac{2}{\pi}$$

$$\Delta V_p = 2\pi r\,x\Delta r + \pi r^2 \Delta x$$

by neglecting 2nd and 3rd order derivatives. This may be expressed:

$$\Delta V_p = \pi r^2 x \left(\frac{2\Delta r}{r} + \frac{\Delta x}{x}\right) \qquad (4)$$

but $\pi r^2 x = V$

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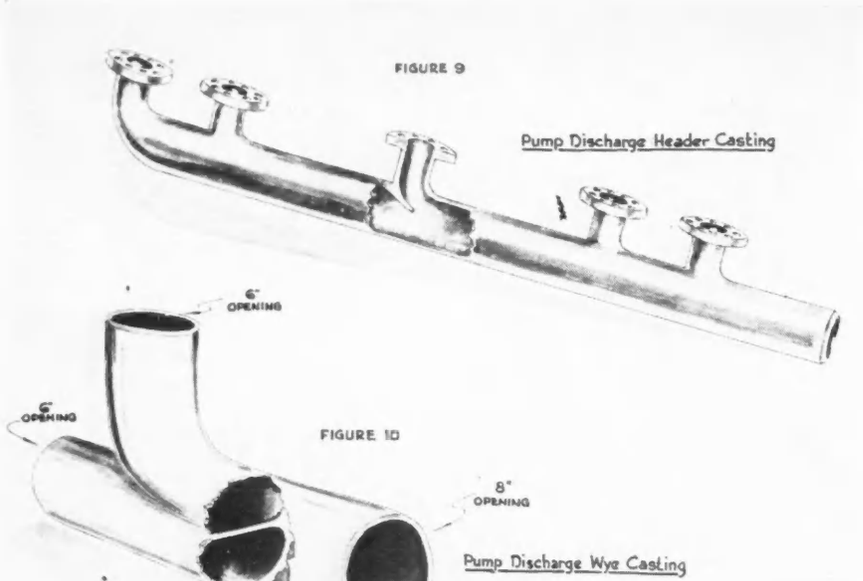

Then substituting (2) and (3)

$$\Delta V_p = \frac{Pr}{2tE} V \cdot \left(5 - \frac{4}{\alpha}\right) \text{ for the pipe} \quad (5)$$

By definition

$$\frac{\Delta V_L}{V} = \frac{P}{K} \text{ or } \Delta V_L = \frac{PV}{K} \text{ for the liquid} \quad (6)$$

$$\Delta V = \Delta V_p + \Delta V_L$$

$$\frac{PV}{J} = \frac{PrV}{2tE}\left(5 - \frac{4}{\alpha}\right) + \frac{PV}{K}$$

$$\frac{1}{J} = \frac{r}{2tE}\left(5 - \frac{4}{\alpha}\right) + \frac{1}{K} \quad (7)^6$$

$$C = \frac{12}{\sqrt{\frac{M}{g}\left(\frac{1}{J}\right)}} = \frac{12}{\sqrt{\frac{M}{gK}\left[1 + \frac{rK}{2tE} \cdot \left(5 - \frac{4}{\alpha}\right)\right]}} \quad (8)^6$$

For crude oil in steel pipe.

Assuming $K = 200{,}000$ lbs./sq. in;
$E = 30 \times 10^6$ lbs./sq. in.
$M = 53$ lbs./cu. ft.; $\alpha = 3.33$

(8) reduces to:

$$C = \frac{4180}{\sqrt{1 + 0.0127 \frac{r}{t}}} \text{ ft./sec.} \quad (9)$$

Joukovsky has developed a formula which does not account for the longitudinal pipe movement. Since this small factor may be neglected, we may also use:

$$C = \frac{12}{\sqrt{\frac{M}{gK}\left(1 + \frac{2rK}{tE}\right)}} \quad (10)^{7,8}$$

Or for the same valves as in (9).

$$C = \frac{4180}{\sqrt{1 + 0.0133 \frac{r}{t}}} \text{ ft./sec.} \quad (11)$$

Notes on Air Chamber Calculations

Since the advent of the use of equalizer lines in our system, it has not been found necessary to use air chambers or alleviators on the discharge side of reciprocating pumps. In order to provide for constant flow of the oil mass by a cushioning or smoothing effect on the suction side of the slower speed duplex and triplex pumps, particularly where the installation is not a flooded or positive pressure suction, it is felt highly desirable to use air chambers at the pump.

However, where the frequency of volumetric change in the pump cycle becomes compartively high (an estimated 25 cycles per second or more) and the volumetric change in the resultant flow curve of the pump is small, it is not felt necessary to introduce an air chamber. Here it is believed that (1) the inertia of the oil mass is such that it will not follow these changes in volume and (2) the amount of volume variation in a properly operating pump of five or more cylinders at a speed of 175 rpm or greater is insufficient to justify the use of an air chamber.

Calculations for sizing air chambers following the equations developed by Professor E. H. Kennard[9] and those which we have developed on the basis of sizing the air chamber so that the air and oil act as a resonant spring mass system have borne out these observations. This latter derivation is not included here because of its narrow usage in practice. A few field observations have also been made to further substantiate this view.

ACKNOWLEDGMENT

The writer wishes to express gratitude to all who have been so helpful in assisting in the preparation of this paper. Representatives of the Aldrich, Worthington, National Transit, and Cooper-Bessemer companies have furnished valuable data and sources of information. Much credit is also due to the members of the engineering staff and the departments of the Stanolind Pipe Line Company for their constructive criticisms and ideas offered, particularly T. R. Aude, J. R. Polston, A. H. Newberg, H. L. Drake, R. P. Lennart, and C. F. Gearhart. J. B. Eisler and T. Gilmartin of Stanolind Oil and Gas Company have also been generous with their time in helping to formulate some of the conclusions herein expressed.

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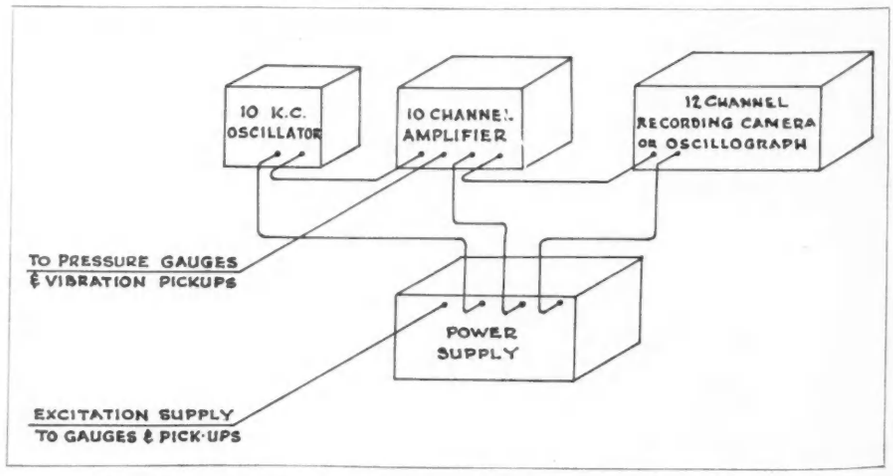

10 K.C. OSCILLATOR
10 CHANNEL AMPLIFIER
12 CHANNEL RECORDING CAMERA OR OSCILLOGRAPH
TO PRESSURE GAUGES & VIBRATION PICKUPS
POWER SUPPLY
EXCITATION SUPPLY TO GAUGES & PICK-UPS

FIGURE 11. Cabling diagram. Vibration and pressure measuring equipment.

INCREASE DURABILITY... MINIMIZE REPLACEMENTS

of Cast Parts in Oil Field Equipment

by using NICKEL ALLOY STEEL CASTINGS

THIS "CHRISTMAS TREE" CARRIES PEAK LOADS

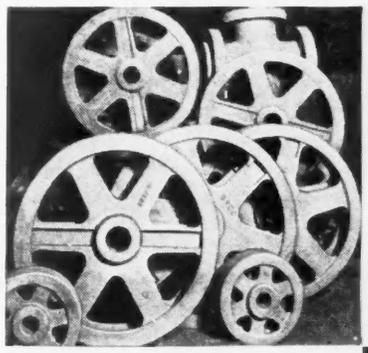
Here are flanged crosses, tees and fittings of cast nickel-chromium-molybdenum steel, produced by Los Angeles Steel Casting Co., Los Angeles, for Regan Forge & Engineering Co., San Pedro, Calif. After normalizing and drawing at 1200° F., these castings show:

Tensile Strength, p.s.i.	100/110,000
Yield Point, p.s.i.	75/85,000
Elongation in 2", %	18/22
Reduction of Area, %	35/45
Brinell Hardness	200/235

ADVANTAGES

of Alloyed Over Plain Carbon Steel Castings

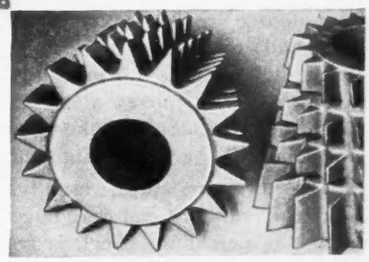
1. STRONGER... HIGHER YIELD STRENGTH
2. LESS BULK and DEADWEIGHT
3. HARDER... MORE WEAR-RESISTANT
4. BETTER RESPONSE TO HEAT TREATMENT
5. GREATER SHOCK-RESISTANCE
6. GREATER FATIGUE STRENGTH
7. LESS EMBRITTLEMENT AT SUB-ZERO TEMPERATURES



BUILT FOR LONG, DEPENDABLE PERFORMANCE

These gear blanks for pump units were cast in nickel-chromium-molybdenum steel by Texas Electric Steel Casting Co., Houston, Texas, for Lufkin Foundry & Machine Co., Lufkin, Texas. The castings were quenched and drawn to provide:

Tensile Strength, p.s.i.	105,000 min.
Yield Point, p.s.i.	75,000
Elongation in 2", %	22
Reduction of Area, %	55
Brinell Hardness	260-290



CAST NICKEL ALLOY STEEL STANDS THE GAFF

These case-hardened rock bit cutters were cast in a steel equivalent to 4615 type (nickel-molybdenum steel) by Westelectric Castings, Inc., Los Angeles, Calif. They exemplify use of nickel alloy steel castings for service which demands materials far above average in strength, hardness, toughness and dependability.

Nickel alloy steel castings have excellent wearing qualities and withstand combinations of severe static and dynamic stresses. Applications include:

Brake drums	Core tube pullers
Pump bodies	Slush pump valves
Crown block sheaves	Bit bodies and cutters
Traveling block sheaves	Slush pump liners
Drilling valves and fittings	Draw works gears and sprockets

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Company.....

W. O. 3-49

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THE INTERNATIONAL NICKEL COMPANY, INC.

67 WALL STREET
NEW YORK 5, N. Y.

Handling Long Pipe

By ELMER WEAVER

STRINGING of pipe along the right-of-way has been a one-line job ever since pipe was last rolled off a wagon and lugged into place by the gang and sets of special tongs. This method of passing a sling, chain or clamp around the middle of a joint works fairly well for the 20-foot joint, but when used with a 40-foot double, requires expert steering at the hands of the two or more men who must "tail on" to the pipe to guide it as the crawler moves along the ditch from the truck dump to the point where the joint will be welded into the line.

The swinging pipe, usually moved with the rearward end dragging to minimize the pendulum effect, is frequently damaged by being banged against adjacent joints of pipe, rocks or stumps. Pipe thus deformed may be lost as scrap, or it may cause serious delays as attempts are made to round out the dented end to make it align properly for welding.

One pipe-stringing contractor uses old drill pipe to make a special heavy-duty side boom for his tractors, fabricating the boom long enough to enable it to reach over a pile of pipe and pick up any joint without dragging it across others which may be nearer to the lifting point. This extra long boom, pivoted to the tractor frame at the usual points for side booms, is fitted with a tee-shaped head so that instead of carrying one block for the hoisting line, a pair of blocks may be slung from eyes at the ends of the tee. Dual lines are strung from the drum. One winds from either end of the drum so as to give even take-up on both, and each terminates in a pipe hook and steady line.

Final Stringing

Using the two lines, and attaching one hook to either end of the joint of pipe, the pipe is handled in the final stringing just as it is lifted at the mill, in the yard, or at railroad loading points.

When using the paried lines for handling pipe, it is found that the affixing of the two hooks, after pulling out slack on both lifting lines, takes more time than is demanded by the one-line method—if the pipe lies so that a sling or chain can be passed readily around the middle of the joint. If the pipe must be blocked up, swung around or otherwise jockeyed into position before the lifting line can be attached, the dual line method not only is less likely to result in damaged pipe ends, but also is faster.

With two hoisting lines spread as widely apart as possible at the masthead, one man at a tailing line can control the swinging of the joint, even when the tractor is proceeding across timber riprap, and the pipe can be guided into place as it is lowered without the necessity of the free end being allowed to swing.

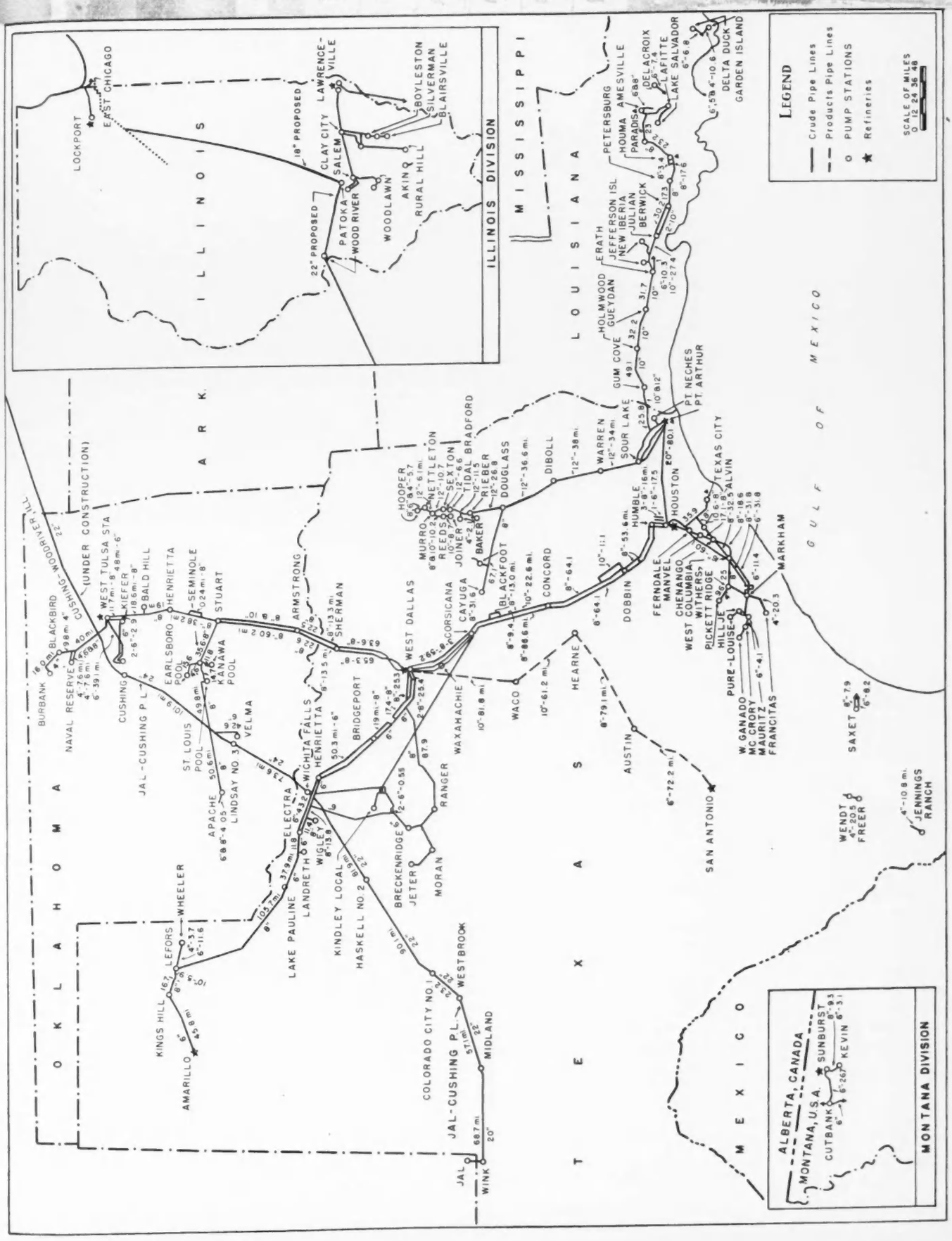
Use of dual hoisting lines allows the topping lift block to be attached at the center of the mast crosstree, and aids in keeping that line clear of the hoisting lines while making a lift and at the same time varying the elevation of the boom.

The dual lines are brought from the masthead blocks to a paired guide sheave mounted on the tractor, and are then led over a wide cylindrical roller before reaching the hoisting drum. The frame that carries this hoisting line roller also supports a second and higher roller which takes the load of the topping lift when the boom is laid down close to the ground. Use of the dual rollers and flanged guide fingers prevents possible interference between the various lines in the vicinity of the drums and insures proper separation when the boom is lifted.

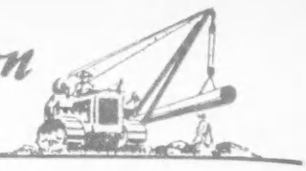
Pipe Lines of the U.S.

The Texas Pipe Line Company

60th of a Series



PIPE LINE *Construction*



PREPARATIONS for constructing the Texas-to-New York City gas pipe line, the longest in the world, were advanced materially the past month as initial pipe shipments were made and financing arrangements completed.

Trains, consisting of 100 car-loads of 30-inch line pipe each, started moving out of Consolidated Western Steel Corporation's California mill in February bound for Texas and the longest pipe line project ever undertaken. This natural gas line is to be built by Transcontinental Gas Pipe Line Corporation and will extend from Southwest Texas to New York City, a distance of 1840 miles. Actual pipe laying is scheduled to begin in April.

Final financing plan included the raising of $26½ million through sale of interim notes payable later in preferred stock and $22½ million by sale of common stock. In addition, $143 million of first mortgage bonds, 3 5/8 percent, due in 1968, were sold to 18 large insurance companies.

Pipe Line Construction

Table includes projects planned, contracts awarded, and spreads or entire projects completed since the February 1 issue of WORLD OIL.

Company	Origin and Terminus	Length (Miles)	Pipe Size (Inches)	Daily Capacity (Barrels Cu. Ft.)	Remarks
CRUDE OIL LINES					
Atlantic Refining Company	At Atreco Terminal, Port Arthur, S. E. Texas	8¾	12-16-18	.....	Job completed by Acme Construction Co., Kilgore, Tex.
The California Company	Near Ruston, Louisiana	40	6 & 8	.....	Construction by Latex Construction Co., Houston, scheduled to start Feb. 10.
Horowitz Pipe & Supply Company	Take-up of line near Collinsville, Illinois	12	6	.....	Completed by Bill Morrison Construction Co., Tulsa.
Interstate Oil Pipe Line Company	Elk Basin field, Carbon County, Montana to Billings and Laurel, Montana	70	12	40,000	Proposed system to supply additional refinery capacity now building. Plan calls for one pumping station at origin. Contracts not let.
	Point 7 miles south of Maysville Station to Company's Tussy station, Oklahoma	17	12	.....	The 12-inch will be an extension to Interstate's trunk from Panther Creek Jct. to Okla. City.
	From new 12-inch at Foster, Okla. to Elmore City, Okla.	5	8	.....	O. C. Whitaker Co., Ft. Worth, expects to complete both lines by mid-March.
Ohio Oil Company	East Sparta to Canton, Ohio	6	6 & 7	.....	Completed by Sheehan Pipe Line Construction Co., Tulsa.
Sinclair Pipe Line Company	Take-up and recondition gathering system near Seminole, Okla.	95	4-6-8	.....	Work started in late January by Bill Morrison Construction Co.
Southern Pipe Line Corporation	Edroy, Texas to Corpus Christi, South Texas	14	6 & 7	.....	Sheppard-Geiger Construction Co., Corpus Christi, started work in late January.
Stanolind Pipe Line Company	First loop from Kellerville Jct. to Center Station, Missouri Second loop from Mill Creek Jct. to Auburn Station, Mo. Third loop from Orchard Farm Jct. to West Bank, Mississippi River Jct.	64	12	.....	These 3 loops on Stanolind's LaPlata, Mo. to Wood River, Ill. line have been completed by Sheehan Pipe Line Construction Co.
PRODUCTS LINES					
Sinclair Refining Company	Bond Street, Upper Darby, Penna. to "G" St. and Hunting Park Ave., Philadelphia	14	8	.....	Contract completed by John Meehan & Son, Philadelphia.
NATURAL GAS LINES					
Atlantic Seaboard Corp. and Virginia Gas Transmission Co.	Clendenin, West Virginia to Rockville, Maryland	268	26	.....	Application made to FPC. 193 miles in W. Va. and Md. will be built by Atlantic and 75 miles in Va. by Virginia Gas. Line will cost $20 million and must be completed by March 1, 1950.
Harrington & Marsh	Gathering system in Texas County, Oklahoma	12	.....	.....	Work started by Knupp Construction Co., Great Bend, Kans.
La Gloria Corporation	Gathering system, La Gloria field, Jim Wells Co., S. W. Texas	14	8 to 26	.....	Altgelt Construction Co., Corpus Christi, started construction in January.
New York State Natural Gas Corp.	Rasselas, Penna. to State Line Station, Penna. loop	31½	16	.....	Work started by Williams Bros. Corp., Tulsa, and scheduled to complete July 1.
The Ohio Fuel Gas Company	Reed-Scipio Twp. line, near Attica, Ohio, to Jct. of T-50 & D-100 lines near Lime City, Ohio	40	20	.....	Mahoney Contracting Co., Mt. Pleasant, Mich, has contract and will start about June 1.
Oklahoma Natural Gas Company	Take-up, recondition and relay in Tulsa area	20	6-8-12-16	.....	Work completed by Western States Construction Co. Inc., Oklahoma City.
Parade Gasoline Company	Take-up in vicinity of Turner Town, East Texas	5	8	.....	Started by Titsworth & Partain, Kilgore, Texas.
Phillips Petroleum Company	Gathering system to Hansford Plant, Texhoma, Oklahoma	90	8 to 24	.....	To be completed about March 1 by Vaughn & Taylor Construction Co., Inc., Wichita Falls.
San Diego Gas and Electric Company	Southern Counties Gas' proposed 16-inch line at Rainbow, Cal. to San Diego, Cal.	50	16	40 mln	Application made to FPC. Line will cost $3,037,500 and will be part of 85-mile project from Tex-to-Cal. line to San Diego. Southern Counties Gas Co. has applied for first 35 miles.
Stanolind Oil & Gas Company	Gathering system, Fullerton field, Andrews Co., West Texas	25	2 to 22	.....	Deaton & Sons, Inc., Odessa, Tex., has completed project.
Texas Eastern Transmission Corp.	Waskom field to TETCO 24-in., Jefferson, East Texas	29	8-10-12	.....	All four lines completed by Brown & Root, Inc., Houston.
	Bryceland field to TETCO 20-in., Bienville Parish, La.	1	7	.....	
	California Gasoline Plant to TETCO 20-in., Lincoln Parish, La.	2	12	.....	
	Southwest Gasoline Plant to TETCO 20-in., Lincoln Parish, La.	5	12 & 14	.....	

The trend in the oil-field is toward portable derricks, not only for servicing-units, but also for drilling deep wells. FWD trucks, mounted with derricks, have been important factors in saving material and labor through these modern methods of drilling and servicing wells.

IN OIL-WELL DRILLING . . . AND OIL-WELL SERVICING

FWD TRUCKS DO MORE WORK

Modern portable derricks, mounted on FWD 6x6 trucks, offer many important operational advantages in oil-well drilling and servicing.

With driving-power and sure-gripping traction on all six wheels, these big FWD trucks go through swamps, loose sand, broken terrain, up and down steepest slopes, if necessary, to get to the sites of remote oil-wells.

FWDs have the advantages of full power and traction on every wheel, for hauling heavy loads of steel casing, pipe line pipe, ponderous equipment, and heavy materials. For heavy-duty jobs of all kinds, FWDs are always dependable. They do more work!

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PIPE LINE HINTS

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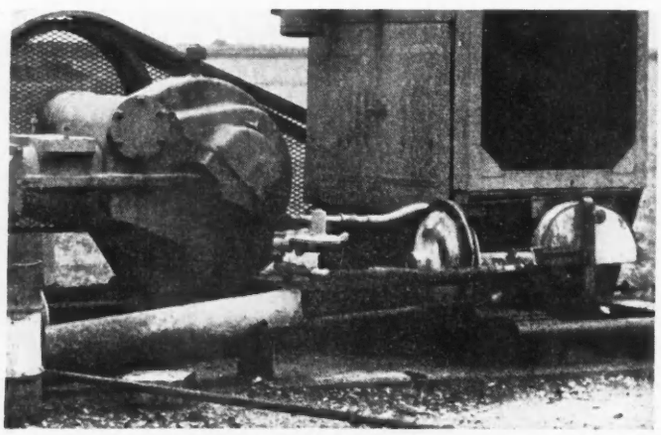
HOW TO—Clean Gas Used for Pump Engine and Starter



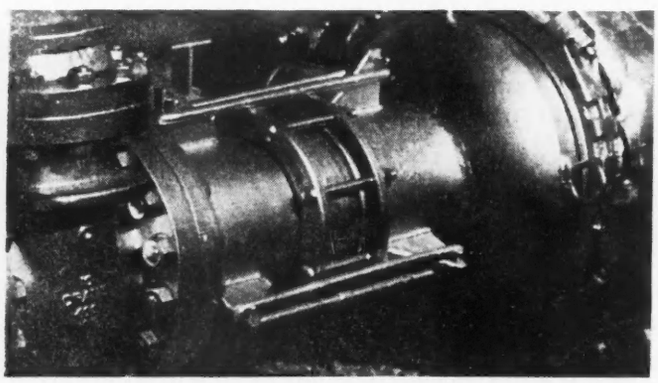
The removal of moisture and liquefied petroleum gases from fuel gas is important to the continuous operation of pipe line pumps. It is also important that liquids be prevented from entering the driving diaphragm of the pneumatic engine starter. A simple, yet effective way to knock out any liquids entrained in the field gas system is illustrated.

The method takes advantage of an inclined section of eight-inch casing approximately six feet in length. It is welded closed at both ends, the field gas input section resting on the pump foundation, while the opposite end is elevated some six inches by a piece of plate steel welded to the bottom side of the chamber.

Gas enters the scrubber or cleaner at the lower end through a one and three-fourths-inch line connected to the field gas system. The increased area of the casing permits any liquids in the gas to drop out or condense and flow to the lower end. Any solid particles are also dropped from the flow stream in the scrubber.

Gas discharges from the casing at the elevated end where a tee has been connected. One side of the tee is connected to the pneumatic engine starter which operates at line pressure, while the other connection is to a pressure regulator which drops the gas pressure to five or six ounces. A valve connection on the lower end of the scrubber permits periodic draining and cleaning. The unit has operated satisfactorily, and though the gas is not heavily laden with liquids and solids, it has prevented the relatively small amounts of each from entering the equipment supplied gas.

HOW TO—Snub Sleeve Couplings Against High Pressures



At one pumping station, the exhaust from the prime movers was piped to heat exchangers placed in the main line in order to heat up the oil and thereby decrease its resistance to flow. The The heat exchanger installation required three exchangers placed side by side connected through valves at each end to a common manifold. When the exchanger became clogged, it had to be removed and replaced with a clean one. Due to large volumes pumped through the line, it was necessary that this changing of heat exchangers be done in a minimum of time.

Removing the exchangers from the line and installing clean ones was facilitated by the use of sleeve type couplings at either end of the exchanger as shown. Due to relatively high pressures handled by the line, it was necessary that the sleeve couplings be reinforced to hold them together. To provide quick removal of the coupling, and at the same time offer adequate reinforcement, three slip bars fitting over extension "ears" were employed.

The nipple extending from the manifold valve and the short extension on the heat exchanger were equipped with three brackets made from half-inch plate steel cut in the shape of a 45-degree triangle and welded to the respective lines 130 degrees apart. The brackets were welded to the pipe in alignment so a slip bar could be placed over the brackets and held in place. These slip bars were usually hammered in place so a tight joint resulted. To keep these slip bars from vibrating off the brackets, a small hole was drilled in the outer edge of the bracket and a cotter pin inserted. The pin was sprung so it would not accidentally fall out. To remove the exchanger, it was only necessary to remove the pin, pull the slip bars and unscrew the sleeve coupling.

Baash-Ross News

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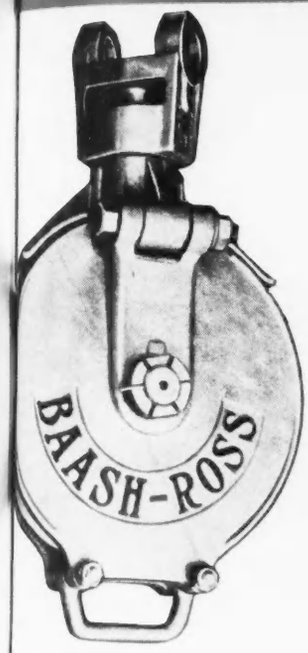
OUR 29th YEAR



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For those small block jobs, here's the most sensible investment you can make–

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Although in average drilling and producing operations there are dozens of different jobs that call for small blocks, you can reduce them all into three principal types of work . . .

1. **Bending lines around corners, such as in snatch-block applications.**
2. **Supporting lines in the rig for lifting tools and equipment.**
3. **Small traveling block applications for reducing line loads during hoisting operations.**

And the Baash-Ross Universal Utility Block is unique in that, simply by changing inexpensive accessory units, this *one* block will handle any of these *three* types of jobs. What's more, its capacity is 39 tons with 2 to 1 safety factor!

For example ...

FLOOR BLOCK: Simply attach a base plate and you have a Floor Block that can be used with portable pulling outfits in well servicing work. Positive stops allow the Block to tilt 45° in any direction and a roller bearing swivel allows it to follow the line freely as it spools on and off the drum. To save time, in moving the Block from rig to rig, you can anchor an inexpensive base plate on each rig floor and quickly mount the Utility Block by inserting just one anchor bolt between plate and Block.

CORING BLOCK: When you need a small block in the crown for handling bailing and coring lines, simply attach a beam hanger unit to the Utility Block, fasten the beam hanger to a crown beam and you're ready to roll.

The hanger can be placed at any convenient point on the crown beam and when tightened, will not slip. The full-swiveling and tilting features permit the Utility Block to follow the line freely, minimizing wear on both line and sheave.

TUBING BLOCK: Fasten a tubing block clevis and your Utility Block is ready to serve as a Tubing Block in a wide range of well servicing applications. The clevis is free to swing from side to side and is also free to rotate . . . or can be locked against rotation by means of a built-in pin. The heavy-duty tapered roller bearing on the sheave gives the unit a high working capacity.

HEAVY DUTY *Performance Features*

Three-way adaptability is only part of the story on the Utility Block. Look at these top quality construction features . . .

- Side opening feature (by simply removing one bolt) saves time in placing lines around the sheave.
- Capacity 78,000 lbs.—with 2 to 1 safety factor.
- Sheave is alloy steel, 18" dia.—with flame-hardened groove 14½" dia.
- Bearings in both sheave and swivel are heavy-duty tapered roller type.
- Full 360° swiveling in all applications—or swivel may be locked by built-in pin.
- High pressure grease ducts direct to sheave and swivel bearings.
- Rope cannot jump sheave—guarded by side plates.

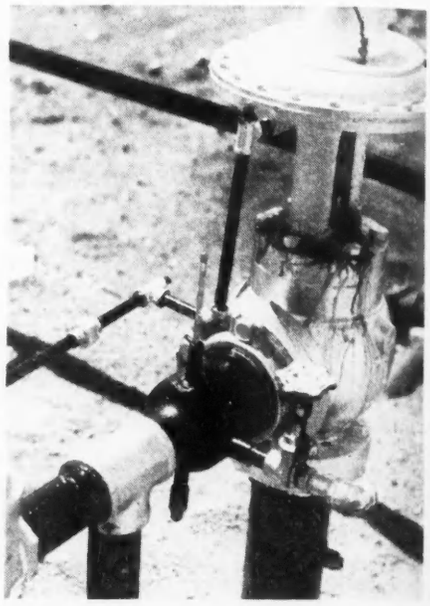
The Baash-Ross Universal Utility Block makes important savings on small-block inventories and it is available grooved for any line from ⅜" through 1".

AVAILABLE THROUGH LEADING SUPPLY STORES

HOW TO—Improve Thermometer Well System

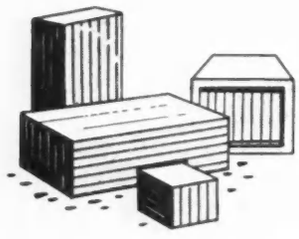
The installation of a thermometer well on a line frequently consists merely of closing the lower end of a small tube, inserting it inside the flow line, then closing the opening by welding a bead around the neck. For an interior installation this method may be satisfactory, but when placed on a line exposed to dust or debris, the tube will gradually fill up, preventing the thermometer from being inserted to its full depth unless the tube is cleaned out by "fishing" or swabbing.

One company found it more desirable to extend thermometer wells through from one side to another in the lead line fitting, the lower end then being fitted with a coupling and solid plug to permit periodic draining of the light oil within the tube. In addition, a sample cock is welded into the side of the same fitting beside the thermometer well, this arrangement makes it possible to draw fresh well fluid up around the well and

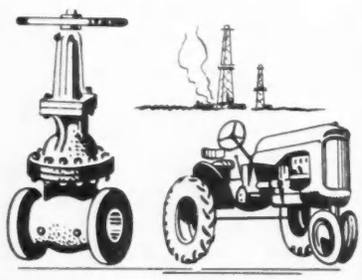


results in a more accurate or representative temperature of the sample fluid.

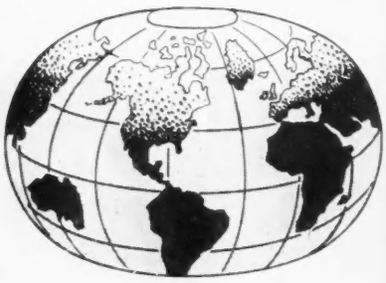
ANY TYPE CRATE



FOR ANY KIND OF PRODUCT



TO GO ANYWHERE



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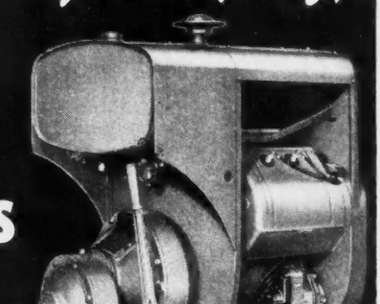

Here is a 475-lb. power package that delivers 30 hp. at 2000 R.P.M. — designed and built for dependable, heavy-duty service outdoors or indoors. It's the Model VP-4, V-type, 4-cylinder Wisconsin Air-Cooled Power Unit.

Compact V-type design simplifies installation on a great variety of equipment and efficient AIR-COOLING takes care of all cooling problems . . . at any season, in any location.

Heavy-duty engineering features include: Tapered roller main bearings, dynamically balanced crankshaft, mirror-finish crank-pins, honed cylinders, and molybdenum iron valve seat inserts. High tension rotary type outside magneto is equipped with Impulse Coupling for quick, easy starting in any weather.

For utmost dependability . . . specify "Wisconsin Engine". Supplied in a complete power range from 2 to 30 hp., 4-cycle, single cyl. and V-type 4-cyl. models.

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PIPE LINE HINTS

HOW TO—

Swing Power Sheave

In bending relatively large diameter line pipe in pipe-bending machines, a side boom cat places the joint in the machine. It is a manual operation to hook up the power sheave to the extending end where the pull is to be made. These heavy-duty sheaves or blocks sometimes weigh more than 100 pounds and require two men to extend the power cable and fix the block to the joint of pipe.

Alleviating this lifting job is a unique device added to a pipe bending machine. Purpose of the device is to hold

the heavy block off the ground at the same height as that of the stationary block fixed to the frame. The block is supported by a horizontal arm braced to a vertical riser. The vertical element of the support is of four-inch pipe, and is inserted into a four-foot section of six-inch pipe welded to the bending machine frame.

An extension to the vertical element above the horizontal arm provides a chain bracing for the arm. The chain is hooked into the extended end of the arm, passes over the vertical extension and is anchored to the frame. Heavy coiled springs carry the weight of the pulley and cable, making it possible to adjust the pulley over slight vertical distances without lifting the entire weight.

When the bending machine is to be moved, the blocks are detached from the springs and the chain brace disconnected. The supporting arm thus freed, it can be removed from the frame and carried on the unit without interfering with loading or unloading operations.

Coat Your Pipe at St. Louis

standard pipeprotection, inc. . . . offers minimum *through* freight rates with "in transit" storage facilities

1 When you ship through the St. Louis gateway you use "through freight rates" instead of the higher combination rates generally used. This in-transit privilege permits stop-off for processing or storage up to 12 months at St. Louis without freight penalty.

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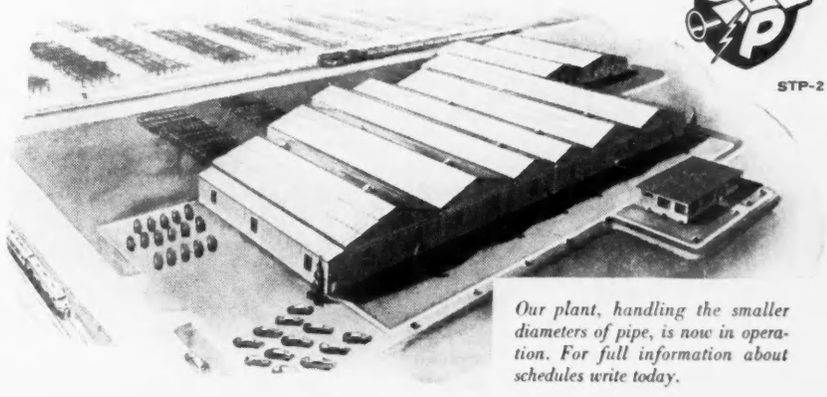


Our plant, handling the smaller diameters of pipe, is now in operation. For full information about schedules write today.

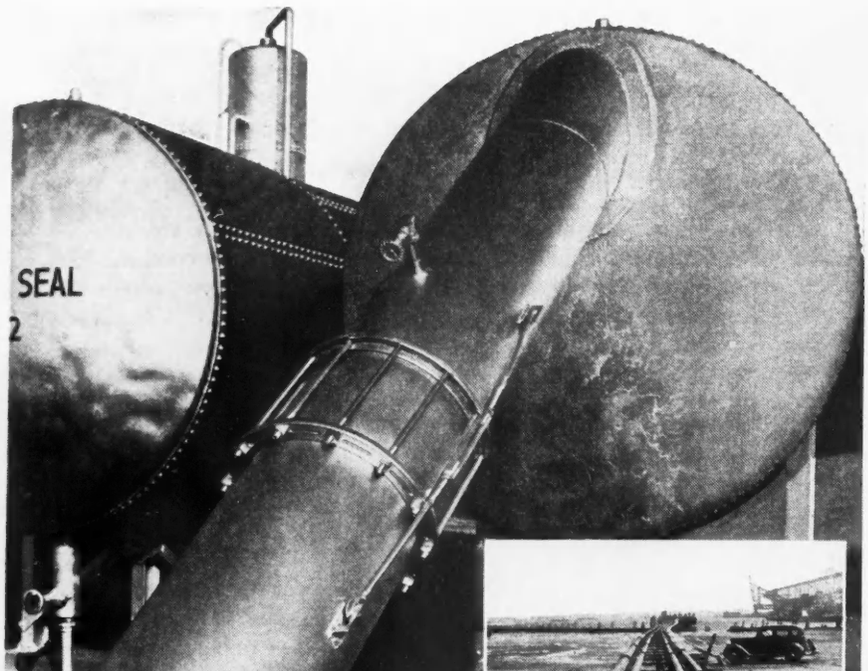
HOW TO—Make Sling for Handling Plastic Coated Line Pipe

In handling line pipe that has been coated, particularly somastic coated pipe, it is necessary that extreme care be exercised so that the coating will not be injured. Common practice is to employ a belt sling that can be quickly wrapped around the pipe and hooked to the lifting cable of a side boom tractor. Such a sling as shown can be easily made in the welding shop from one-inch rod material. Not only is it of adequate strength, but its construction is such that little time is lost in making it ready for use.

Essentially, the sling consists of three primary parts: the canvas or leather belt sling about 12 inches in width, and two triangular steel end pieces. One end piece is completely welded closed in the shape of an equilateral triangle, approximately 16 inches on each side. It is cross-braced with a smaller piece of steel rod. The other end piece is made similarly, except instead of being made in the shape of a triangle, it is in the form of an inverted "V" with large eyes welded at the ends of the vee. It is also cross braced. A large pin of the same stock material is fitted with a head to prevent it from passing through the eyes. A handle is welded to this head so that it can be handled easily. The belt is permanently sewed to the completely closed triangle, with only a loop sewed to the opposite end.

In handling coated pipe, the belt is passed under the pipe, and the large pin threaded through it and the eyes in the open end piece. A loop of steel cable attaches the end pieces to the hook on the lifting cable. The sling can be easily uncoupled to take another lift.

HANDIEST... wherever you have pipe to join



Whether it's an equipment hookup, a field line, or a terminal—anywhere you're joining pipe—the handiest, surest way to get uniformly tight pipe joints is with Dresser Couplings and Long Sleeves.

There's no pipe threading—the only tool you need is a wrench. Dressers give you a "Flexible-Tight" connection every time, day or night, rain or shine, even where pipe ends don't meet.

Get Dressers from your nearest oilfield supply store, or at our Houston warehouse.

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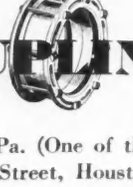


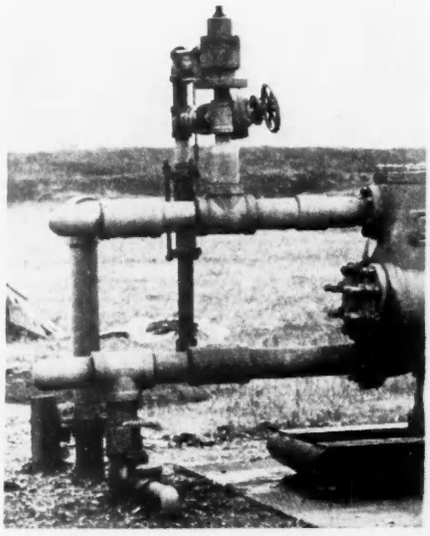
Dresser Manufacturing Division, 59 Fisher Ave., Bradford, Pa. (One of the Dresser Industries). Houston Office and Warehouse: 1121 Rothwell Street, Houston, Texas. Sales Offices: New York, Chicago, Houston, San Francisco.

HOW TO—Avoid High Pressures

The very low order of the compressibility of crude makes it necessary to take some precautionary measures in its transportation through pipe lines. If, for any reason, the discharge line should become closed, the pressure on the line will continue to build up until something

breaks—either the pump or the discharge line. On many remote pipe line pumping installations, provisions are made to stop the pump when the discharge pressure reaches an unsafe point. This type safety shutoff requires that the prime mover be stopped.

Another safe and efficient method of accomplishing this end as far as remote installations are concerned, is the hookup shown. Several advantages are apparent, not only for safeguarding the maximum pressure to be permitted on the



discharge line, but also in priming the pump. A popoff or pressure-relase valve is added to the discharge from a tee on the line. Exhaust from the pressure relief valve is tied into the pump suction. In addition, there is a manual control which by-passes the regulating valve.

In the event the discharge line should be closed due to closing a main line valve accidentally, or a safety valve closing due to a line break, the pump continues to build up discharge pressure. When this pressure reaches some predetermined value within the working limits of the equipment, the pressure regulating valve opens, thereby permitting the oil to discharge into the suction. The pump then merely circulates the oil without adding to the upstream pressure.

The manual valve control serves to aid in priming the pump when started. A 1¼-inch line taps the suction line to fill up the pump suction from a source set aside for this purpose. Once primed, the manual controls are closed and the pump discharges into the main line.

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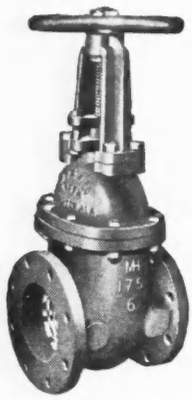
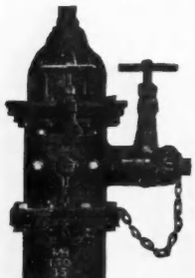
VALVES, HYDRANTS
And Pipe Line Accessories



M & H valves for water, gas, steam, oil, chemicals, are furnished in all commercial sizes from 2" to 30", inclusive. They are cast iron body, bronze mounted, furnished double disc parallel seat or solid wedge. They are heavily proportioned and have a high factor of safety.



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M&H VALVE
AND FITTINGS COMPANY
ANNISTON, ALABAMA

PIPE LINE HINTS

HOW TO—Counterbalance Oil Loading Swings

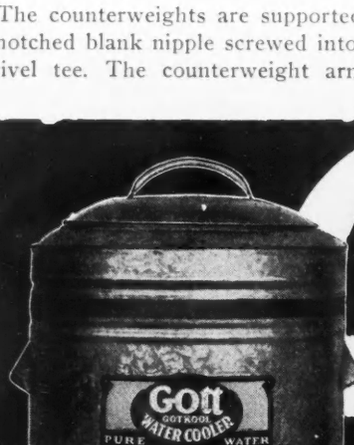
Where leases are remote and not near pipe lines, it is necessary to truck the oil from the lease tanks to the pipe line. When a considerable amount of trucking must be done from the lease, much time can be saved by constructing adequate loading facilities.

Proven satisfactory by years of performance is the loading swing shown. The pump in the background transfers the oil from the tanks to the truck. It is electrically operated and is controlled by explosion-proof switches mounted near the loading valve on the loading swing. The truck operator standing on top of the truck and observing the fillup, controls this switch.

Unique in this particular loading arrangement is the method of counterbalancing the swing. The fittings are relieved of the counterbalance weight by supporting this weight by a suspension attached to the swivel tee. The load is carried by that part of the loading line screwed up tightly and by the swivel. The loosely fitted ell which permits up and down movement of the swing is relieved of the counterweight load with the result that oil is not lost at the oil connection.

The counterweights are supported by a notched blank nipple screwed into the swivel tee. The counterweight arm is

pivoted at this point by a short extension hinged to the blank nipple. A vertical extension of the swing pipe is attached to the outer end of the counterweight arm to hold the loading line in almost a horizontal position. The weights thus adjusted make it possible for the truck operator to easily place the loading line nozzle into the truck tank loading hatch with little effort.



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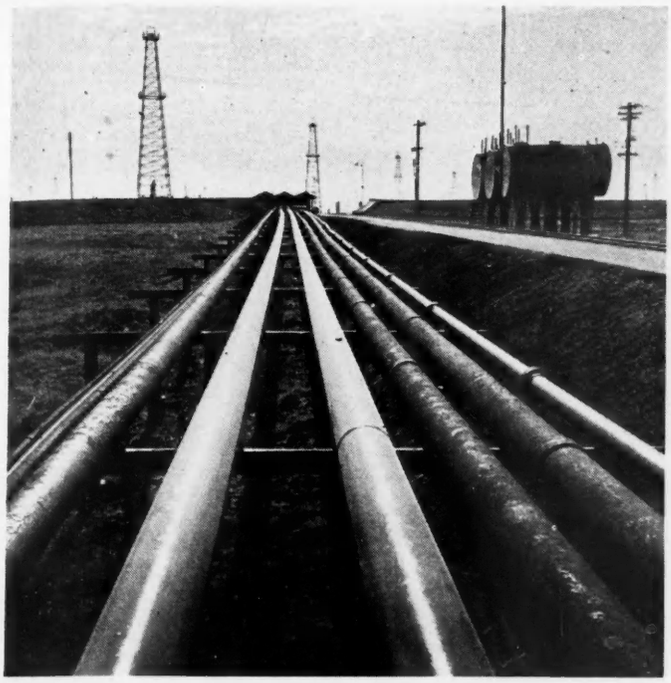


Loading lines from shore storage to tankers at Lagunillas, largest producer of heavy crude in the Maracaibo area.

Forced by Weak Heavy Fuels Market

By HENRY OZANNE,
Staff Writer

CUTBACKS in Venezuela's oil production totaling about 150,000 barrels a day already have been effected, and there are prospects for further decreases later this year. Colombia production is dropping, too, and may not be able to maintain present rates which are 4000 barrels a day under those of 1947.

First reversal since 1941 in Venezuela's upward production trend is due to two factors, one economic and the other technical. The economic factor is the basic one of the weakening of the world petroleum market; the technical factor is filled storage capacity in Venezuela, especial for heavy oils. Venezuela is finding herself in growing competition with the Middle East in the world market, especially since the companies operating there are surrendering their options for re-purchase of their own royalty oil.

The heaviest production cutback has been made by Creole in Venezuela. By Mid-February Creole had decreased its schedule by 114,000 barrels a day from the peak of 658,000 barrels daily of last September. Creole's cutbacks are in Bachaquero and heavy Tia Juana, La Rosa, medium Tia Juana and Quiriquire oils. About 75 percent of the entire cutback has occurred in the Lake Maracaibo region.

Creole cut its crude prices 5 cents to 20 cents a barrel January 16 and followed shortly afterward with another 5- to 15-cent a barrel cut on various grades. With its first price reduction, Creole reduced output by 108,000 barrels daily, and with the second, cut back another 6000 barrels a day. Creole's prices and production drops follow the recent price decreases averaging about 23 cents a barrel on heavy fuel oils in the U. S. market. The situation was reflected in the reduction by Creole of its dividend from 90 cents to 75 cents February 4.

31 Percent to U. S.

About 31 percent of all Creole's production found its way into the U. S., chiefly through importation by Creole's parent company, Standard Oil Company (N. J.).

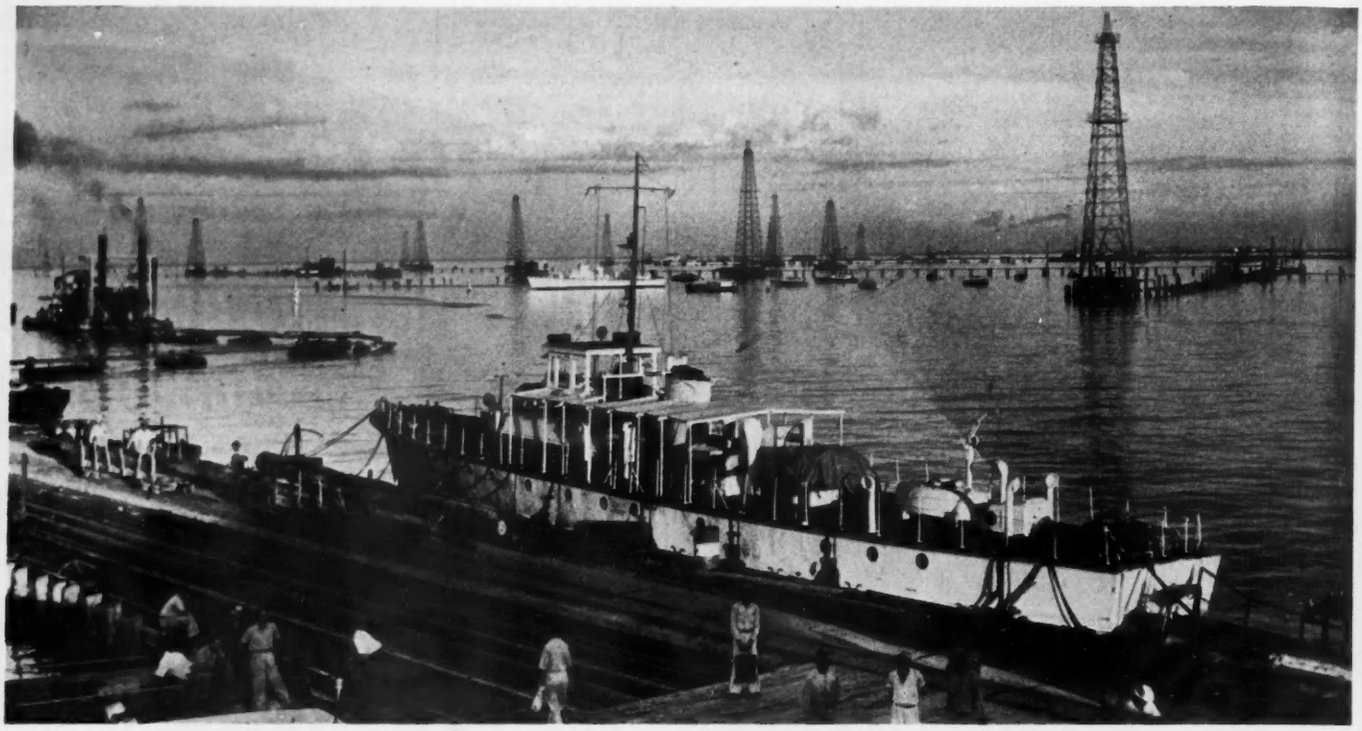
R. W. Miller, Creole vice president in charge of sales in Venezuela, said the production cutbacks were ordered to "avoid chaotic market conditions." He added that world production had reached a peak six months ago and that further storage for surplus production is not available. He predicted that within 1949 Venezuelan production would find a stable level at about 10 percent below last year's peak. Creole brings up about half of all the oil produced in Venezuela.

Gulf Oil Corporation, through subsidiary Mene Grande, has cut back production in Venezuela by 27,000 barrels a day, and foresees another reduction of around 16,000 barrels daily. "Lack of storage and lack of outlet" was the explanation given by a Gulf official.

So far The Texas Company plans a cutback in production only at Tucupita, where its daily production of 7500 barrels will be decreased to 3600 barrels. Production of around 15,000 barrels a day at Mercedes, and 13,000 barrels a day at Mara will be maintained for a few months at least.

Shell, second largest Venezuela producer, has made no immediate reduction in output but is standing ready "for whatever action is dictated by the law of supply and demand."

The weakening situation in Venezuela was first indicated by the decision of Shell and Gulf that with expiration of their present purchase contracts, they would pay no more than regularly posted prices, comparable with those of West-East Texas, for their royalty crude. Shell's option, first to lapse, was for 2 million barrels a month. This action may be offsetting against Shell's continuing



View over loading docks at La Salina showing offshore wells in northern part of Lake Maracaibo producing area.

schedule of full operations in Venezuela. The Texas Company next lapsed its purchase option, and it is expected that Creole and Socony-Vacuum will do likewise with the end of their contracts next November.

This action could throw back to Venezuela around 75 million barrels a year of royalty oil which the country would have to seek to market elsewhere. It is understood that Venezuela was able to recontract with Portugal for Shell's lapsed 2 million barrels a month, but it is believed that future sales contracts may be more difficult to obtain.

In line with the production cutbacks, drilling operations are being curtailed somewhat. Creole has taken off three rigs in the Maracaibo area. Gulf announces that it is curtailing its drilling activities only slightly. The Texas Company already has cut back on its drilling program after completion of its 80-well project centering around Mercedes. It now has only five rigs running there as against 11 a year ago. Shell is maintaining current rate of activity for the present.

In Colombia, 1948 production may not reach much more than 23 million barrels, a decrease of more than 1 million from 1947. The 1948 reduction was forced chiefly by strikes and hence a restoration to former levels would actually be a downward trend in Colombian production. Eighty-four wells were drilled in Colombia in 1948. Tropical Oil Company, Shell and Texas are maintaining present production schedules in Colombia.

None of the companies is curtailing exploration work either in Venezuela or Colombia and Texas is planning to expand its exploration survey in Colombia over an 88,000-acre concession recently granted on the island of Salamanca and adjacent tidewater in the state of Magdalena.

Temporary camp for seismograph operations in Eastern Venezuela. Companies plan no reduction in exploratory work.

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Speeds Mozambique Exploration

AERIAL reconnaissance with the mapping camera and airborne magnetometer is speeding exploration work by the Mozambique Gulf Oil Company of its 42,000 square mile concession area in Portuguese East Africa. Preliminary aerial magnetic maps covering 7000 linear miles of the survey have already been delivered.

This work is being done by Aero Service Corporation of Philadelphia, under contract with the company. The Gulf Research & Development Company's high sensitivity magnetometer is being used in this first air survey of Africa.

The concession area in southeast Mozambique is chiefly grassy flatlands, marked by few rivers and streams, and dotted with native villages. It is a famous game country, with elephants, lions, hippos, rhino and other wild life in abundance, and plagued by the dangerous tsetse fly. Though Mozambique's terrain looks like a U. S. Coastal plain from the air, the climate is tropical, very hot in summer with a rainy season extending from November to March. The country's economy is chiefly agricultural.

Staff Base

Mozambique Gulf Oil Company has established its operations base at Inhambane, a coastal village of 5000 population. This also is the base for the Aero Service survey staff, working under direction of J. C. Heggblom, Gulf's manager of the entire Mozambique exploration program. A grassy field serves as the runway for Aero's DC-3 survey plane, while the village harbor facilities are used in the movement of survey equipment, parts, gasoline and other supplies. Most important, the base is a reasonably central location within the survey area, so that minimum time is consumed in flying to and from sections to be covered in each day's work.

Lourenco Marques, capital of Portuguese East Africa, is 288 miles from

Part of the survey staff (left to right): J. Frank Morgan, magnetometer staff; Frank McWilliams, co-pilot; Thomas O'Malley, project engineer; Joseph Mullen, chief pilot; J. C. Heggblom, manager of Mozambique Gulf Oil Company's exploration program in Portuguese East Africa; Dr. Arthur Yates, a visiting geologist; Frank Baumann, crew chief; E. F. Peterson, magnetometer chief.

Inhambane. The city has a number of hotels and theatres and is a noted recreational spot. Lourenco is the main headquarters for Gulf's staff, and Aero's magnetometer data personnel are also working there.

First members of the survey crew flew to Mozambique in July, 1948, after three months of intensive planning and one previous visit there for first-hand information on operating problems. The program was laid out so that the survey plane could cover the entire area from the one operational base. After installation of extra gasoline tanks, de-icer boots and other equipment, the plane was flown to Africa via London, Senegal, Liberia and the Congo.

Training the Crew

Next came the training of the crew. This work is handled by Thomas O'Malley, who has a background of ten years in aerial mapping. His crew includes a chief pilot, co-pilot, mechanic, photographer, magnetometer chief and assistant, data section chief and two assistants. The magnetometer personnel are electronic engineers who made the pioneering commercial flights with the Gulf instrument in Canada and later played an important part in Aero's operations in the Bahama Islands survey.

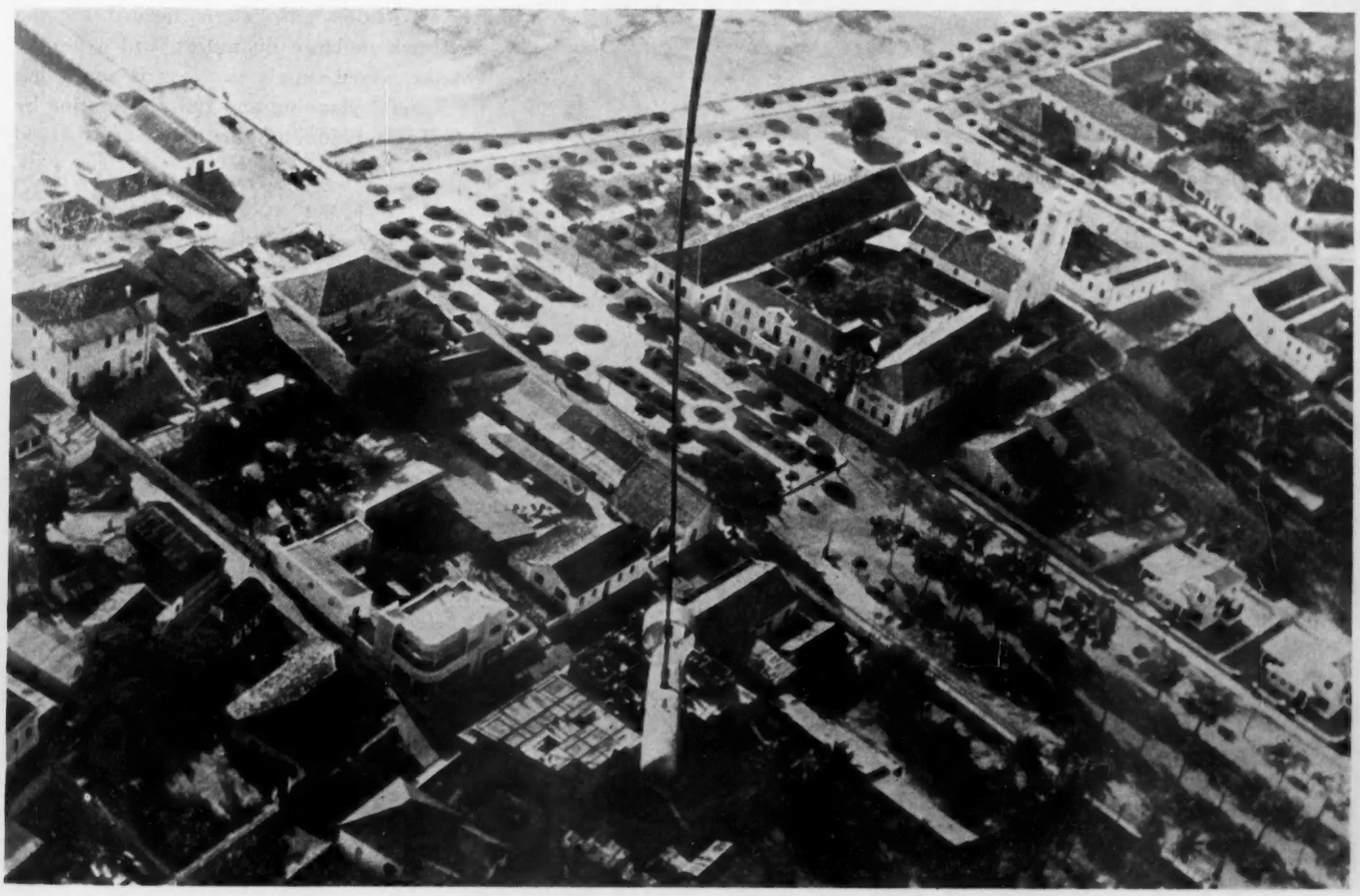
Over a 60-day period these men were briefed on the area, warned of diet regulations, and given a checkup plus a series of inoculations.

At the same time the crew was readied, shipments were moving from Aero's Philadelphia offices to Africa. Most supplies went by boat; 21,000 pounds were crated for overseas shipment. These shipments often required eight to ten weeks for delivery, while emergency air deliveries were made in a week.

With the arrival of the survey staff in Africa, the first job was the preparation of photographic flight maps. It was found that the survey work could be speeded by a two-plane aerial mapping operation, so another pilot-photographer came out from Philadelphia. Flying a locally-leased plane, photo coverage went rapidly by the crew. First photo flights were started in mid-July last year. From an altitude of three miles, mapping planes covered Mozambique's savanna in a series of overlapping pictures which later were assembled into flight maps at a scale of 1:45,000.

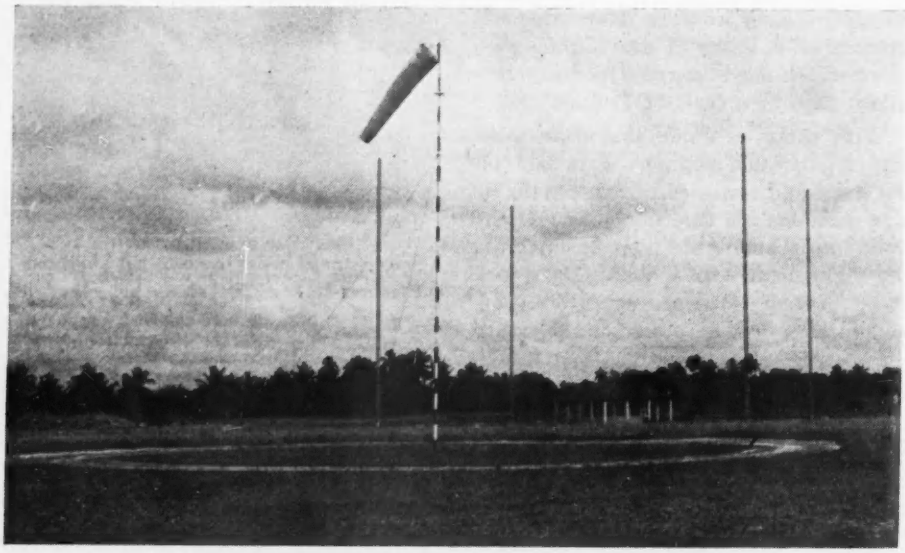
With these to guide the magnetometer flights, the magnetic data can be observed and recorded accurately. Relative positions are determined and developed into absolute positions by integrating flight maps with a radial plot whose basic control is geodetic positions located in a coastal triangulation net,

A native strings the antenna to aid radio communication between the survey plane and its base at Inhambane.



Airborne magnetometer trailing from the plane, seen here over Inhambane.

Refueling is a business of hand-pumping the gasoline from drums. Native laborers at Inhambane help with the task.



Radio shack and windsock, at the grass landing field at Inhambane.

based on existing control established by the government.

After flight maps were completed over much of the area aerial magnetic work began. With the Gulf magnetometer, variations as small as two gamma were recorded in a continuous trace. The survey's plane position in flight is continuously recorded by a special strip camera so that flight path is precisely related to ground positions recorded earlier in the photo flight maps.

Weather permitted photo flights about one day out of seven, and airborne magnetometer flights on an average of five days out of seven. From mid-July to November, about 21,000 square miles of aerial photography had been completed and 16,000 square miles of mapping-magnetometer survey finished. By November the rainy season caused suspension of flights.

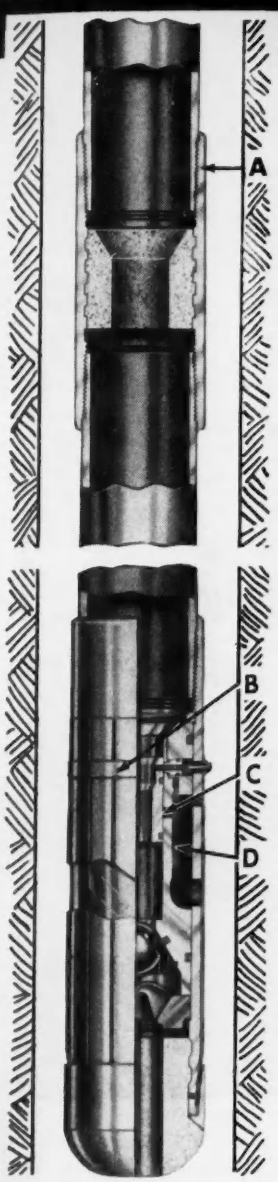
At Lourenco, the field data staff aids in the preparation of flight maps and checks the aerial magnetic data from day to day. After inspection, the air data are shipped to Philadelphia where Aero's home office staff is assembling them into precise aerial magnetic maps.

These maps will be the basis of extensive study by Gulf geologists and geophysicists. The magnetic data serve as a guide toward areas of interest where further ground studies by other methods will be undertaken.

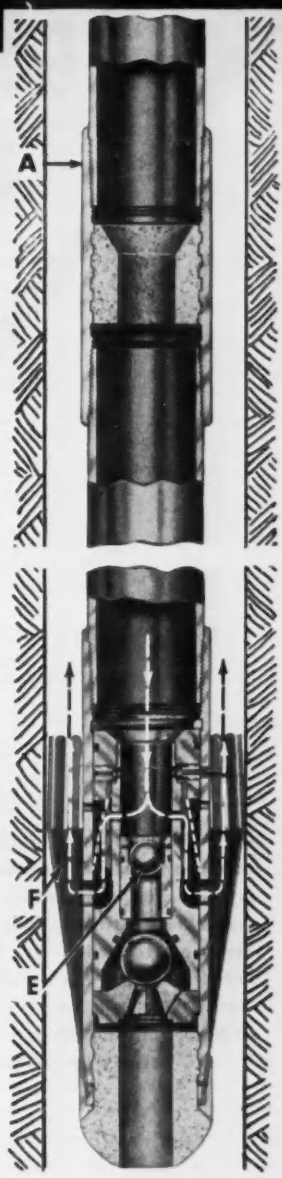
Aviation gasoline is needed for the work in large quantities, and generally the whole supply problem is acute, but careful planning and full cooperation by Mozambique authorities have speeded the work.

The coastal village of Inhambane, operational base for the survey, as seen from the survey plane.

HERE'S HOW THE *Triplex* CEMENTING SHOE BRINGS YOU "BAKERESULTS"



Ⓐ Baker Triplex Cement Baffle Collar, installed a joint or two above the shoe, serves as a stop for the cementing plug. Ⓑ A hold-down strap (secured by shear screws) retains the Baker Metal Petal Basket close against the shoe or collar while running-in the casing and conditioning the hole. Ⓒ Cementing ports are covered by the Tripping Valve until cementing is commenced. Ⓓ A fabric-reinforced, resilient rubber, sleeve-type, back-pressure valve opens readily (see dotted white line) to permit passage of the cement slurry into the annulus above, but closes instantly to prevent any return flow of the slurry. Ⓔ After reaching the desired point in the hole, circulation is established through the ample central passageway. A Tripping Ball now is pumped (or allowed to gravitate) down the hole to seat upon the Tripping Valve. Pressure of 400 to 500 psi is applied to the casing, which shears the Tripping Valve shear screws and forces the Tripping Valve downward to expose the cementing ports. Ⓕ Shearing the screws also releases the Basket hold-down strap and allows the Metal Petal Basket to expand outwardly against the wall of the hole. The Basket with which each Triplex Shoe is equipped has a wide range of expansion and forms a bridge in large-diameter, or irregular-shaped holes far beyond the range of a rubber packing element. The cementing operation now is carried out in the conventional manner with the cement slurry directed upward with the exclusive Baker "Whirler" action. This "Whirler" principle has proved to be far superior to an undirected jetting action which does not minimize the hazard of channeling, and may wash out cavities and cause cement contamination. Only readily drillable materials are used for all internal parts; and two one-half inch set screws hold the inner assembly stationary to facilitate drilling out.



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Collar (Product No. 137) which is *not* equipped with a float valve, but acts as an effective stop for the cementing plug;

(b) Baker Triplex Flapper Valve Float Collar (Product No. 134 M&F) which not only serves as an effective stop for the cementing plug, but provides the added safety of an additional float valve. See illustration for details of the bevelled-top, hollow magnesium casting with a hole of sufficient inside diameter to pass the 1¾-inch O.D. Tripping Ball used with all sizes of Triplex Equipment; see also illustration on opposite page.

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All types of Baker Triplex Cementing Equipment can be secured promptly in API sizes from 4½" to 8⅝". Any Baker serviceman or Baker office will gladly provide additional information and see that your needs receive immediate attention.

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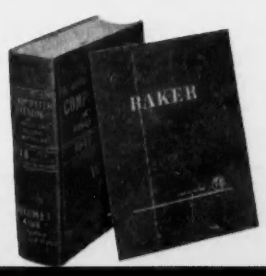


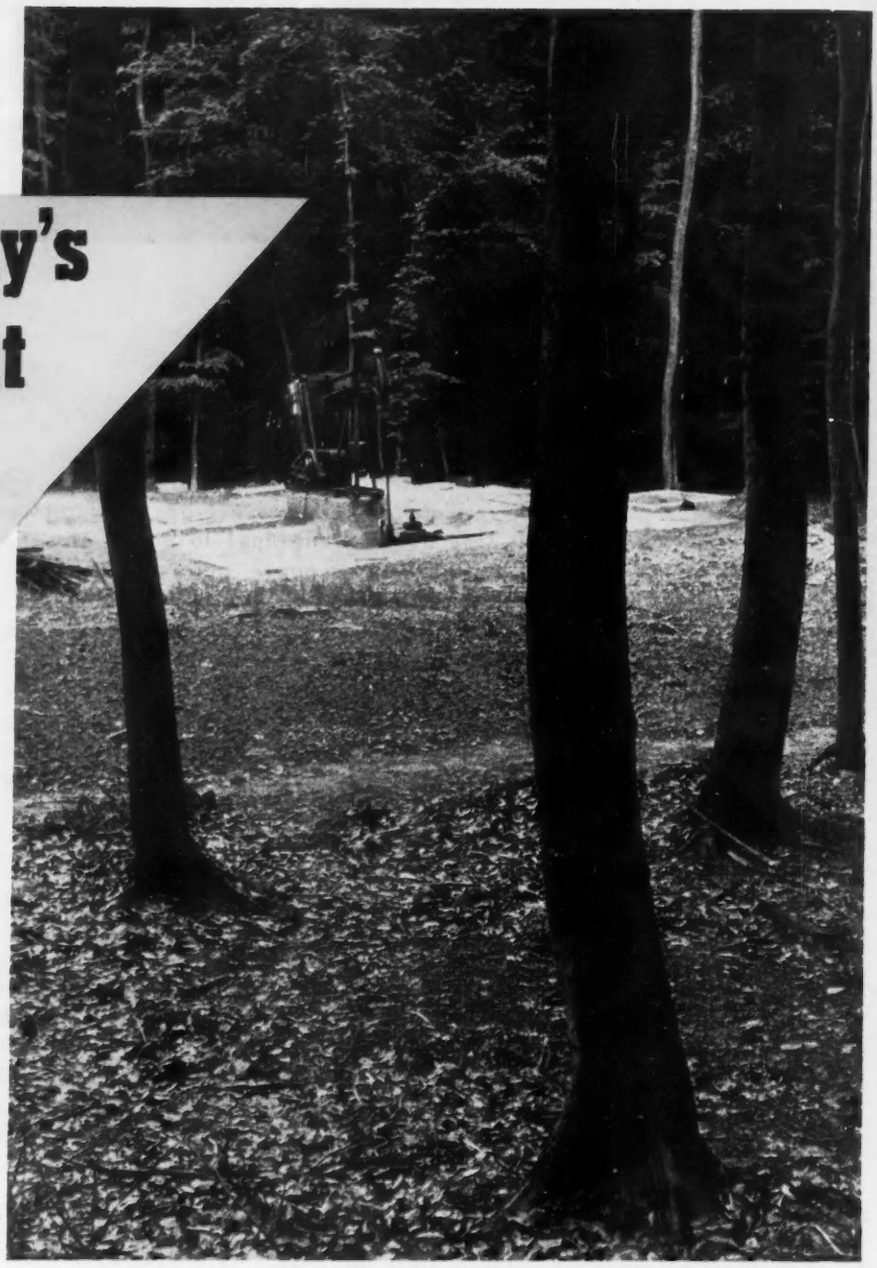
BAKER *Triplex*

CEMENT[illegible] EQUIPMENT

Germany's Output Up

By GEORGE O. IVES
International Editor

WITH ITS older fields declining, German operators are concentrating on newer areas and sharply increasing exploratory drilling. They expect to increase production by 15 percent and drilling by more than 100 percent in 1949, following increases of 10.4 percent and 50 percent respectively in 1948.



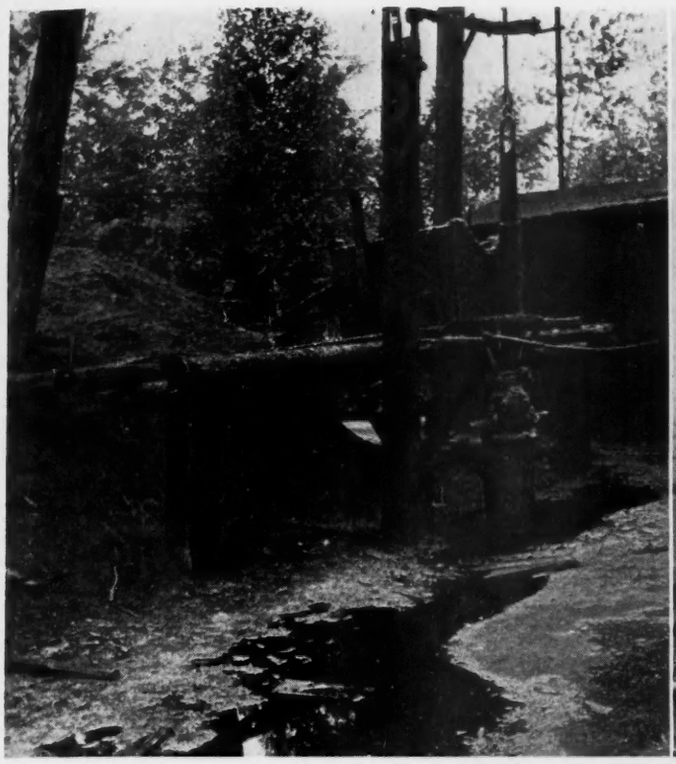
Pumping well in Hohenassel field, Hanover area.

LARGELY through the satisfactory development which brought the fields of the Emsland well above their past production levels, Germany last year increased its output more than 10 percent over the 1947 figures. The total 1948 production of 4,495,593 barrels compares with an output of 4,080,719 barrels in 1947, and it has been estimated that 1949 will see a further increase of about 15 percent.

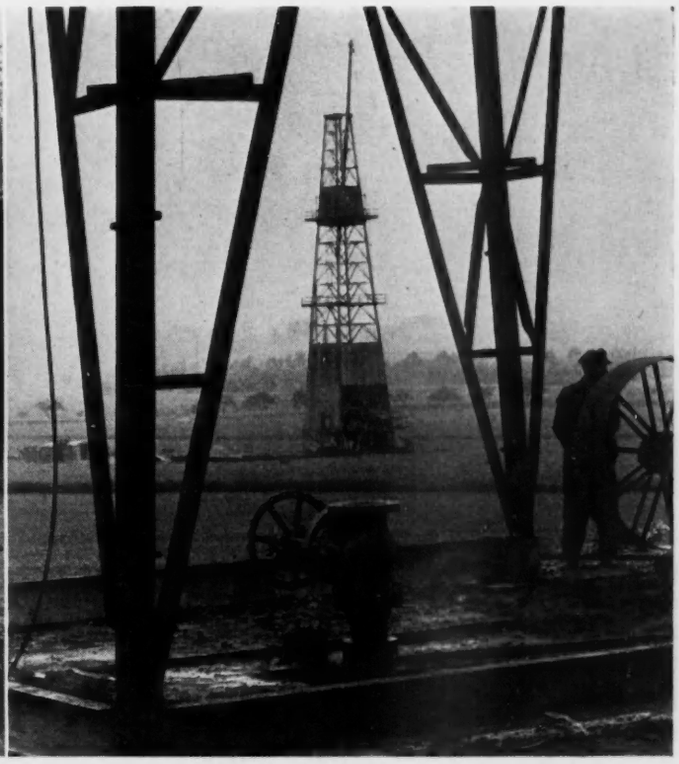
Surprisingly, although the Emsland fields of Emlichheim, Adorf, Georgesdorf and Lingen are largely responsible for the over-all increase, the older areas were able to hold up their yield much better than had been expected. Success in holding off declines to the minimum in these areas was credited to the active exploratory campaign which added a few minor producing sectors, and to the general increase in development drilling. Most of the fields in northwest Germany were subjected to such severe drains during the war years that it is unlikely most will recover.

Again, in forecasting a possible production of 5,160,000 barrels for 1949, special hopes are held for the Emsland fields in achieving such a goal. It is anticipated that the fields in this group will account for at least 34 percent of the nation's production in 1949, whereas they produced in 1948 approximately 26 percent of Germany's output. A goal of 1,788,000 barrels has been set for the Emsland fields in 1949, or more than 600,000 barrels above the past year's yield. Particularly gratifying was the boost in production in the Georgesdorf field. Discovered in 1944, this field produced 375,760 barrels in 1948, or more than the entire cumulative production had been up to the beginning of 1948. This field, important for the 130-foot pay section, has not yet been fully defined, and an important well is now being drilled which may point the westernmost limits of the producing reservoir.

Emlichheim, now the second largest of Germany's producing fields, accounted for a substantial increase in output with 458,943 barrels of oil produced during the year. The new Adorf field only went



A stripper well at Wietze, Germany's oldest oil field. This well was completed before the turn of the century and still produces intermittently.



Stemmer Berg 4, a wildcat near Hanover which found small production. In background rigging up is in progress on Stemmer Berg 5.

on production during the past year, and produced a relatively small amount, while Lingen was boosting its output by 25 percent.

In the Hanover region, the Nienhagen-Haenigsen field is still the largest single source of production, but the 1948 output of slightly more than 880,000 barrels was 7½ percent less than 1947, and represents a continuation of the sharp declines which have been apparent for the past several years. This field has accounted for more than 37 percent of all the oil ever produced in Germany, but is now declining at alarming rates. However, its decline has been more than offset by increases at Hademsdorf, Fuhrberg-Hambuehren and Wesendorf, where vigorous exploration has brought some new areas into exploitation.

Declines are also apparent for the Schleswig-Holstein-Hamburg area, where the over-all decrease would have been more alarming but for boosts in output from Reitbrook and Meckelfeld which helped to offset a 38,000-barrel decline in the Heide group of fields.

Table 1 shows total production in 1948 from the various fields in Northwestern Germany and Badonia.

Division of acreage ownership among the various fields in Germany is such that there was very little change in the proportion of the total production produced by operators in various categories. Privately-owner German companies produced 65.8 percent of the total yield, as compared with 66.7 percent in 1947. The companies owned by foreign private capital produced 21.1 percent as compared with 21.4 percent the previous year, while the German state-owned organizations, principally through their greater participation in the Emsland fields, accounted for 13.1 percent of the production, a definite gain over the 11.9 percent participation in 1947 recovery.

TABLE 1

REGION AND FIELD	PRODUCTION (Barrels) 1947	1948
Emsland:		
Adorf	.....	15,308
Emlichheim	367,975	458,943
Georgsdorf	171,052	375,760
Lingen	268,225	337,842
	807,252	1,187,853
Hanover:		
Etzel	29,525	31,372
Steimbke	293,511	294,049
Eilte	608	1,727
Hademsdorf	40,226	66,644
Thoren	121,901	121,795
Wietze	150,931	163,160
Fuhrberg-Hambuehren	300,327	337,884
Nienhagen-Haenigsen	951,878	880,400
Eicklingen-Wienhausen	95,787	92,313
Wesendorf	315,536	360,120
Ehra	4,579	4,331
Gifhorn	10,828	9,236
Calberlah	2,795	3,163
Eddesse-Oelheim	18,705	16,631
Oberg	40,013	40,205
Moelme	34,883	33,495
Broistedt	20,254	28,754
Hohenassel	141,122	133,097
Stemmerberg	.....	722
	2,573,409	2,619,098
Schleswig-Holstein-Hamburg:		
Heide	397,119	358,825
Reitbrook	244,801	272,061
Meckelfeld	13,729	15,010
	655,849	645,896
Total Northwest Germany	4,036,310	4,452,847
Badonia:		
Forst-Weiher	30,056	28,025
Weingarten	14,352	14,720
	44,408	42,745
Total Germany	4,080,718	4,495,593

In order to attain the ambitious 15 percent boost in production for 1949, German economists estimate that it will be necessary to drill new footage equivalent to 325 kilometers (1,066,000 feet), including wildcat and extension tests as well as development drilling. This would in itself be a notable achievement, since it would more than double the footage drilled in 1948.

As now laid out for northwestern Germany and Badonia, the drilling program places particular emphasis on exploratory wells. About 157 wildcats are planned out of a total of 368 wells. In addition, there are 36 extensions to be drilled. The scope of such a program is indicated by the fact that during 1948, when drilling increased materially over 1947, there were 41 wildcats and 16 extension tests drilled. Development drilling calls for 175 wells in proven fields as compared with 116 such wells in 1948.

Total footage drilled in 1948 represented a 50 percent increase over the 1947 volume, with about 525,000 feet drilled in all categories. The emphasis on exploration was apparent in an examination of the drilling record which reveals that more than 234,000 feet of hole was represented in exploratory wells, either wildcats or extensions. This does not include more than 82,000 feet of hole drilled in shallow structure drilling and core holes.

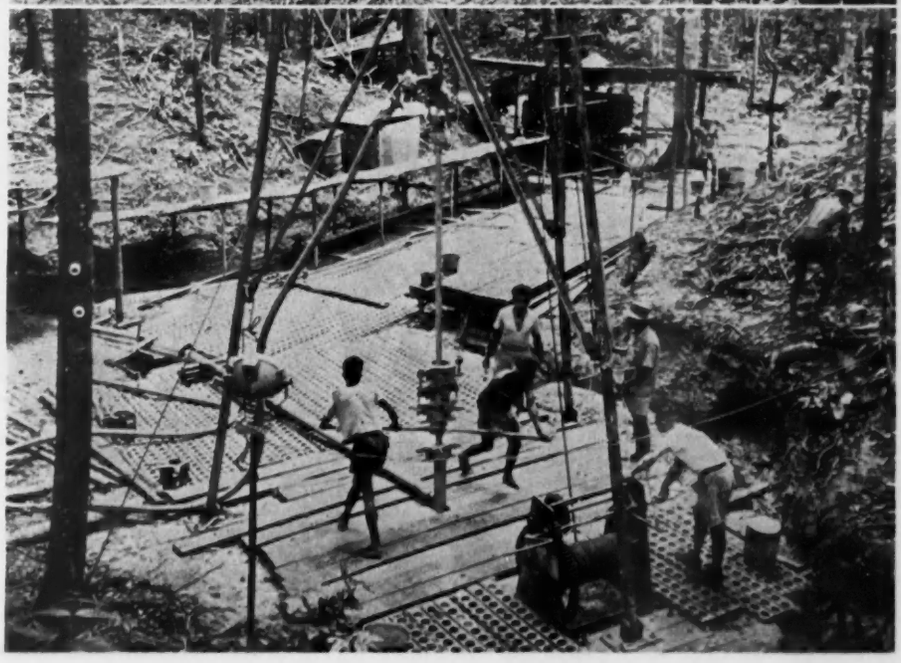
New Guinea Oil

WHEN oil started flowing through the new pipe line from the Klamono field in the heavy jungles of western New Guinea it marked the successful culmination of years of exploratory effort under the most difficult of conditions. Geologists and engineers literally had to fight their way through near-impenetrable jungle growth. Since 1936, when the concession contract was signed whereby the Shell Group, Standard-Vacuum Oil Company, The Texas Company and Standard Oil Company of California teamed up to operate as the Nederlandsche Nieuw Guinee Petroleum Maatschappij, three fields have been discovered, and another shows indications of being of commercial scope.

Resuming in 1946 the operations halted by the war with Japan, the company has developed the Klamono field largely with hand-operated equipment which could be transported in shallow-draft small boats and by hand through the jungle, to the point where a potential of 4000 barrels a day has been built up.

Only 32 miles long, the road constructed from the terminal at Sorong to to the field represented such a feat of engineering that the company experts estimated it would require a year in the building. Actually, it took two years to push the right-of-way and road through the jungle, and complete the eight-inch pipe line.

Now the all-important road gives access to the field with heavy machinery and will make possible rapid development of Klamono field, and testing of the new North Klamono prospect.



TOP (opposite page): Sorong, as seen from the air. Once a tiny missionary settlement; now a busy Nederlandsche Nieuw Guinee Pet. Mij. construction camp and marine oil terminal from which the first shipment of Klamono oil was shipped early this year.

✶

CENTER: Although discovered before the war, Klamono field could not be tapped until the pipe line was built through the dense jungle. Here an engineer opens a valve on the discovery well before it was connected to the pipe line.

✶

BELOW: Torrential rainfall hampered road and pipe line construction. Here workers are interrupted at the job of laying tree-slab walk between Quonsets at Klamono oil field camp. Rainsoaked clay makes hazardous walking.

✶

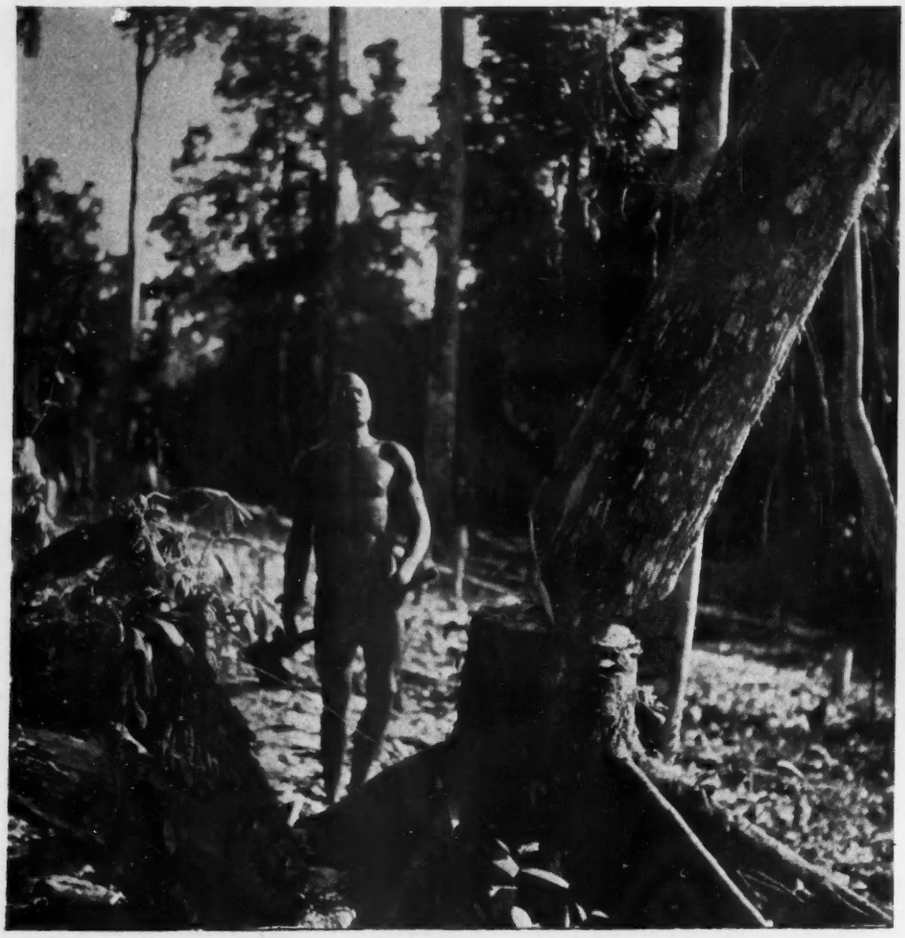
TOP (this page): Traditional native dugout is readily adapted to use of geologists and other personnel by attaching an outboard motor. All early transportation in this rugged jungle was by water, and these craft are remarkably efficient.

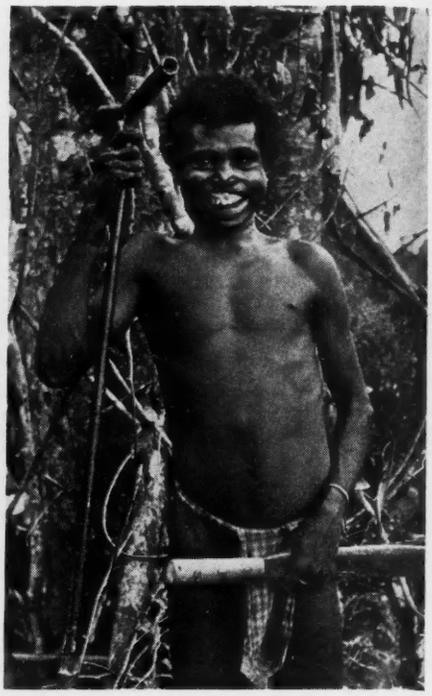
✶

CENTER: Odinary timber-clearing measures had to be supplemented by dynamite and bulldozers in the face of jungle like this. This shows why a 30-mile project took two years to complete.

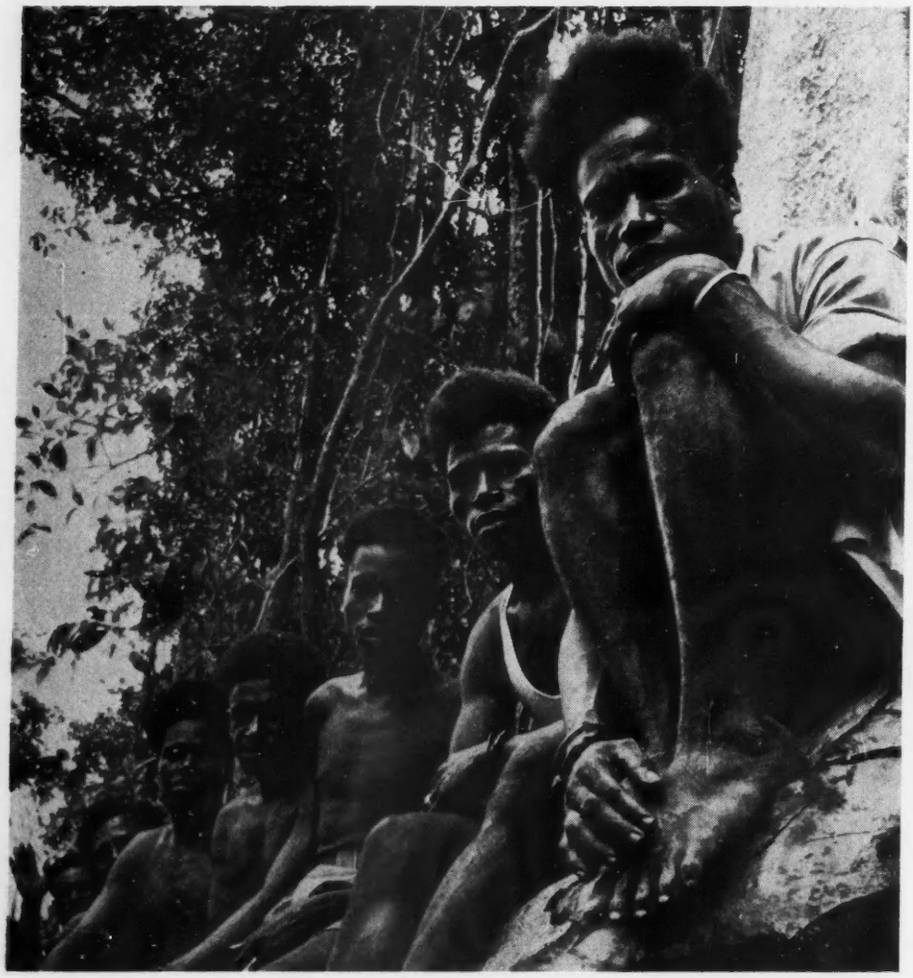
✶

BELOW: Hand-operated rotary rig and light derrick used by NNGPM at Klamono field where back-pack was the only transportation until the road was completed. This outfit has mud circulation and hand-powered drawworks.





ABOVE: After two years of fighting the jungle to bring New Guinea oil to civilization this tribesman seems happy to see the job completed. He is one of 9000 NNGPM employes who hacked a road and communities out of the rainforest.



TOP LEFT: A Vogelkop Paul Bunyan fells a tree along the right-of-way. The first clearing is only the beginning. Constant warfare must be waged against the ever-encroaching jungle to keep the right-of-way open.

LOWER LEFT: Good men in rough country are these jungle-wise New Guinea natives who take rigorous roadbuilding in their stride. Men like these helped to clear the 30-mile strip from field to terminal.

(All Pictures Courtesy Standard-Vacuum Oil Company).

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Aramco Ready for Tapline Showdown

Loaded with line pipe for Tapline between Qatif and Abu Hadriya.

ARABIAN AMERICAN OIL COMPANY was preparing in late February for a showdown on the issue of the long-delayed and much-discussed trans-Arabian pipe line. Unless company officials can untangle two snarls now holding up construction of the line, a new routing will be mapped. The snags are (1) clearance of transit rights from the Syrian Parliament, and (2) approval of an export license by the Department of Commerce for shipment of the pipe.

An Aramco party left the Middle East in late January after waiting nearly two months for action by the Syrian Parliament. Burt E. Hull, president of Aramco's subsidiary, Trans-Arabian Pipe Line Company (Tapline), remained in Beirut with the understanding that when and if he packed his bags and left this time it was for keeps.

Syrian Premier Khled el-Azem announced early in February that negotiations between his government and Tapline had concluded and indicated that formal Syrian clearance for the project would be forthcoming shortly. However, it was understood that Aramco was not prepared to wait longer than March 1 for official approval. On January 28 a preliminary agreement between Lebanon and Syria to allow resumption of work on the pipe line was taken as evidence that the Arab countries are about to settle their differences over the matter and sanction the line.

In case the Syrians fail to ratify Tapline's conventions for construction of the line, the company plans to re-route it directly west across Saudi Arabia from Abu Hadriya to the Gulf of Aqaba, coming below Palestine and Transjordan and thereby remaining in Saudi Arabian territory.

Alternate plans are being considered at that point. The line might span the narrow but deep Aqaba Gulf and continue up the Sinai Peninsula to the Mediterranean, or the line might break with a barge system to bring the oil across Aqaba to Sinai and be recharged to the line for shipment to the sea. Egyptian officials have already said Egypt would build port facilities if the line came out on Sinai.

More Delay

The Trans-Arabian line originally was projected from the Persian Gulf through Syria and Lebanon to terminate at Sidon, Lebanon. The Lebanese government approved rights for the project, but Syria announced that it would not clear the line as long as U. S. policy was endorsing an independent state of Israel in Palestine.

Further delay was encountered due to the fact that the Department of Commerce's Office of International Trade has not yet granted export license for shipment of the pipe.

At the Saudi Arabian fields, a decided decrease in the rate of increasing production is expected for 1949. Production this year will be held down to a 525,000- to 535,000-barrel a day average. While that rate will be a sharp step-up over the 1948 production of around 145 million barrels, it will be at least a 10 percent decrease in the increasing rate of production—that is, somewhat of a leveling off.

New Equipment to Bring More Activity in French Morocco

Recent receipt of drilling equipment from America will make possible intensified effort to establish additional productive capacity in French Morocco.

Additional encouragement was given recently by the opening of another producing area in the Oued Beth region. The new well, drilled by the Societe Cherifienne des Petroles, is about six miles south of the producing area discovered in 1947, and produced oil from a depth of 1800 feet. Later reports indicate that showings have been found in a well drilled between this new wildcat and the Oued Beth field itself. According to official statistics, the field produced 84,000 barrels of oil during 1948, a considerable improvement over 1947 output, but still far short of consumption in French Morocco. The new area will add substantially to the output, since it is estimated good for about 280 barrels daily.

Tunisian Policy Changed

Tunisia plans allow private companies to operate in Tunisia, including the fields in the Sousse and Sfax areas, it is reported. Reason given for this change in policy is the shortage of funds for such an undertaking.

MEXICO

Alarmed by Rising Imports

DESPITE an increase of more than 20 million barrels in annual oil production since 1944, Mexico's rising consumption has forced imports of 130 percent more crude and products than it was bringing in five years ago. A still greater cause for concern is the loss in foreign exchange through the devaluation of the peso, so that while imports amount to 2 1/3 times more than five years ago, the actual cost to the nation in terms of its own currency is more than 4½ times what was spent for imported oil in 1944.

The tremendous rate of increase in the petroleum products imported into Mexico is shown in Table 1. Figures for 1948 have been estimated on the basis of eight months' data now available. Reason the quantity of imports for 1948 is slightly less than 1947 is because labor difficulties in refineries and shipping circles on the west coast of the U. S. prevented the delivery of a number of shipments during the summer months. Imports in 1949 may well be expected to be another 1 million barrels above 1948.

The value of these imports is of particular interest. It will be noted that, although the quantity of deliveries for 1948 is estimated at about 230 percent of 1944 deliveries, the corresponding value in 1948 reaches 315 percent of 1944 values. Still more distressing, from the Mexican viewpoint, is the fact that the rate of exchange between the Mexican peso and the U. S. dollar has changed from 4.85 pesos to a dollar in 1944 to about 7.00 pesos to the dollar (unofficially, since no official rate has been fixed since July 22, 1948). Thus, calculation will demonstrate that 1944's imports amounted to 38,500,000 pesos while 1948's value in pesos at 7.00 to 1.00 will amount to 174,500,000 pesos—an increase of 454 percent in Mexican currency.

This presents a very real problem to Pemex, the Mexican national petroleum organization. First it should be understood that these imports, in the main, are used to supply the northern border section and the west coast of Mexico, two of the fastest growing sections of the republic, economically, and two of the areas most difficult to reach by the interior transportation facilities available in Mexico. It is much more practical, economically, to import products from California for the west coast of Mexico than it is to move tank cars over the width of the republic on the antiquated and inefficient railroad systems of Mexico.

However, as is obvious from the drop in the rate of exchange, dollar credits are at a premium in Mexico. In order to balance out on foreign trade within

TABLE 1

Petroleum crudes and products imported into Mexico 1944-1948

(U. S. Bbls. and U. S. Currency)

	1944		1945		1946		1947		1948 (Estimated)	
	Barrels	Dollars	Barrels	Dollars	Barrels	Dollars	Barrels	Dollars	Barrels	Dollars
Crude Oil	59,603	89,460	80,468	139,940	102,287	204,099	101,350	236,348	63,000	173,000
Gasoline—Aviation	276,480	1,062,978	321,299	1,311,222	328,359	1,329,538	335,336	1,647,051	292,000	1,550,000
Motor	357,177	1,335,094	487,557	1,739,283	1,171,904	3,650,601	1,712,093	6,476,117	1,710,000	8,400,000
Naphtha	1,938	13,332	2,780	19,650	3,846	29,256	5,293	35,218	2,520	24,000
Kerosene	86,216	237,335	117,834	336,433	144,675	449,710	122,482	476,057	98,000	460,000
Gas Oil	205,537	368,573	241,509	441,139	418,103	836,382	557,987	1,377,074	430,000	1,305,000
Fuel Oil	627,320	724,357	583,498	692,325	836,482	1,162,595	1,341,517	2,228,806	1,260,000	2,892,000
Lubricants:										
Red and Pale Oils	29,847	292,644	34,589	327,413	37,795	452,586	59,354	858,645	.....	.....
Black Oils	3,051	25,785	4,574	43,747	7,944	118,740	6,295	66,674	.....	.....
Bright Stocks	16,334	161,057	25,068	251,772	19,864	273,207	38,560	598,444	.....	.....
Steam Cylinder	2,847	28,970	3,087	29,759	2,303	29,748	2,210	22,011	.....	.....
Insul. and Transformer	1,178	15,560	2,737	32,459	3,222	42,673	2,853	42,400	.....	.....
Light Lubes (small pkgs.)	1,423	40,900	612	32,471	726	56,222	2,564	112,374		
High Visc. Aviation	37,002	517,285	54,775	760,305	25,317	406,257	42,176	821,619	.....	.....
Medium Visc. Aviation	73,565	1,108,376	102,496	1,695,723	97,917	1,678,196	67,052	1,194,309	.....	.....
Not otherwise specified	26,263	363,457	43,209	640,566	43,795	700,062	109,088	1,758,432	.....	.....
	191,610	2,554,034	271,147	3,814,215	238,933	3,757,691	330,152	5,474,908	284,000	5,302,000
Lubricating Greases	14,737	333,422	17,682	401,551	25,577	600,134	25,927	748,441	22,000	666,000
Petrolatum and Pet. Jelly	10,436	164,201	4,787	78,918	6,195	116,987	7,474	161,819	2,750	53,000
Paraffin	6,441	93,703	29,041	431,923	14,198	193,595	39,326	952,742	96,000	2,030,000
Asphalt	16,441	47,068	7,004	21,588	24,412	64,726	71,819	215,476	82,000	240,000
Pet. Prod.—not otherwise specified	42,525	779,025	13,329	220,075	48,121	938,384	37,651	884,808	20,000	500,000
Petroleum Coke	1,338	2,854	14,286	23,416	717	2,053	336	981	180	1,000
Liquid Gas	159,806	303,562	251,407	486,568	377,876	841,843	390,108	1,135,944	395,000	1,340,000
TOTAL	2,057,605	$ 7,944,797	2,443,628	$10,020,356	3,741,685	$14,060,607	5,078,851	$21,889,971	4,757,450	$24,936,000
Natural Gas—MCF's	10,008,193	$575,954	12,873,732	$1,098,502	12,998,779	$561,220	7,631,612	$906,509	6,000,000	$1,070,000

Conversion factors used—Lubricating greases and Petrolatum 300 lbs. per bbl.; Paraffin 280 lbs. per bbl.; Liquid Gas 190 lbs. per bbl.; Asphalt 6.16 bbls. per ton; Coke 5.6 bbls. per ton. Petroleum products "not otherwise specified" averaged $18.32 per bbl. in '44; $16.51 per bbl. in '45; $19.50 per bbl. in '46; $23.50 per bbl. used here for '47.

TABLE 2

Petroleum crudes and products imported into Mexico January through August, 1948

	Barrels	(U.S.) Dollars	Comparative Percent Two-Thirds of 1947 Total	
			Quantity	Value
Crude Oil	41,838	115,857	62%	73%
Aviation Gasoline	195,314	1,034,503	87	94
Motor Gasoline	1,137,679	5,600,499	100	130
Naphtha	1,679	16,649	22	74
Kerosene	65,339	306,813	80	95
Gasoil	285,867	870,030	76	95
Fuel Oil	839,342	1,928,451	94	130
Lubricants—Oil	189,552	3,534,832	86	99
Grease	14,620	444,645	84	98
Petrolatum and Jelly	1,841	35,516	37	33
Paraffin	63,982	1,353,375	244	213
Asphalt	54,368	160,070	93	92
Not otherwise specified	67,153	333,927	60	60
Petroleum Coke	118	647	168	140
Liquid Gas	262,961	894,268	101	117
TOTAL	3,221,642	$16,630,082	95	114
Natural Gas (MCF)	4,007,001	712,193	79	119

This eight-month recapitulation thus shows a total drop in imports of 5% annually while the value of the imported products is 14% greater than last year, which reflects an over all 20% increase in price.

the oil industry itself, Pemex would have to export an equivalent value in Mexican oils, and a limited production as opposed to an ever-increasing domestic demand leaves a comparatively small amount available for export in the future.

The picture of Mexican petroleum for 1948 was about as follows: Supplies consisted of a crude production of 160,000 barrels per day plus imports of 13,000 barrels daily, or a total supply of 173,000. Domestic demand (and it may be better to say "domestic actual usage" as the potential demand unquestionably exceeds actual deliveries) was 140,000 barrels per day, which left 33,000 available for export.

Now the ordinary domestic demand for 1949 may be roughly estimated at 10 percent over 1948 or at 154,000 barrels per day, and, in addition, new electrical generating equipment for which Mexico has just secured a loan of $34 million from the U. S. government and which is to be installed immediately, is expected to require about another 10,000 barrels per day of fuel oils by the end of 1949, or a total potential demand of 164,000 barrels per day before the end of 1949.

Production from the four existing fields which supplied 160,000 barrels per day in 1948 cannot be expected to be increased in 1949. Actually, a definite decrease may be looked for in all areas except Poza Rica and a reasonably optimistic estimate of 1949's production would be the same 160,000. The new fields discovered by Pemex near Reynosa in northeastern Mexico may possibly furnish an additional 5,000 barrels daily by the end of 1949 but this area is still definitely in the early development stage and cannot be counted upon too strongly for the coming year.

Thus it may be said that, unless new producing areas are found by Pemex during the year, production will just about equal, and may fall short, of Mexico's domestic demand. Should imports reach the expected 6 million barrels yearly in 1949, these would replace 16,500 barrels daily of domestic oils which would then be available for export. However, this quantity of Mexican crudes and fuel oils (which constitute the bulk of Mexico's petroleum exports) will not equal the same quantity of refined products as shown on the table above, in dollar value.

Pemex authorities are well aware of this situation and plans are being made to try to alleviate matters. One method which will go into effect very shortly is to produce more gasoline at the Isthmus refinery by carrying Poza Rica crude down to the Isthmus in tankers and shipping the gasoline across the Isthmus in tankcars and then delivering to the west coast by tanker. On a straight cost basis, this can hardly be considered worthwhile but, if it will eliminate the finding of several millions in dollar credits, the loss in pesos will be compensated.

The solution, of course, of the whole problem would be the finding of additional oil fields in Mexico, and Pemex is devoting every effort to that end. The break of exchange from 4.85 to 7.00 to 1.00 greatly increases Pemex's difficulties. It can readily be seen that a contract now for $100,000 for drilling a well requires 700,000 of Pemex's pesos while the same contract would have required only 485,000 pesos a few months ago.

For a full and immediate development of Mexico's potential petroleum reserves, it seems very evident that new capital must be acquired. There are possibilities of a U. S. loan to Pemex, but general opinion seems to be that private enterprise could be allowed to enter and share the risks and awards of such development without danger to Mexico's national interests.

TABLE 3

Petroleum crudes and products imported into Mexico, year 1948

(In U. S. Barrels)

	January	February	March	April	May	June	July	August
Crude Oil	5,883	5,327	3,943	2,452	4,853	5,459	3,879	10,042
Gasoline:								
Aviation	29,480	23,659	23,387	29,375	17,590	19,159	33,087	19,577
Motor	184,443	158,998	97,173	198,229	216,417	143,968	99,107	139,344
Naphtha	166	165	273	173	405	191	119	187
Kerosine	13,736	10,661	10,569	7,582	6,397	6,277	5,458	4,659
Gas Oil	98,598	28,272	31,632	27,337	21,852	24,465	30,209	23,502
Fuel Oil	37,056	51,175	117,275	242,233	113,429	89,991	167,538	20,645
Lubricants:								
Red and Pale	2,890	3,969	4,401	5,567	6,074	8,357	8,074	10,387
Black	310	183	.....	132	384	47	171	836
Bright Stock	.....	352	2,886	309	6,476	2,826	1,962	1,484
Steam Cylinder Ref.	.....	.....	1,624	221	134	1,153	1,316	317
Insul. or Transformer (gal.)	5,122	10,774	16,996	10,348	.....	9,909	17,307	34,462
Light Lubes (small pkgs.) (gal.)	21,546	7,103	514	381	2,057	25,846	15,840	2,520
High Visc. Aviation	1,463	320	654	952	1,127	741	914	2,282
Med. Visc. Aviation	3,786	4,061	5,163	6,653	4,393	4,567	5,127	5,258
Lubes not otherwise specified	10,648	6,231	9,378	5,585	7,897	11,787	9,787	7,371
Greases (lbs.)	738,272	613,546	297,436	365,890	743,376	478,345	395,200	753,770
Petrolatum and Petroleum Jelly (lbs.)	17,313	118,900	.....	57,421	73,791	144,994	97,375	42,628
Asphalt (tons)	612	1,138	1,836	1,257	1,352	882	1,141	608
Paraffin—Unrefined (lbs.)	1,185,892	647,753	1,239,926	1,389,338	1,199,367	880,077	1,614,545	1,197,655
Refined (lbs.)	870,199	964,401	549,291	1,109,661	1,764,004	1,278,210	1,606,807	417,789
Petroleum not otherwise specified (at $5.00 per.)	19,743	9,820	6,004	7,111	8,206	8,673	4,996	2,600
Petroleum Coke (tons)	21	.....	.....	.....	.....	.....	.....	.....
Natural Gas (MCF)	426,769	470,038	953,273	41,155	746,329	650,057	264,515	454,865
Liquid Gas (lbs.)	5,643,205	3,434,990	5,001,383	6,670,775	6,887,835	7,758,846	7,476,469	7,089,180

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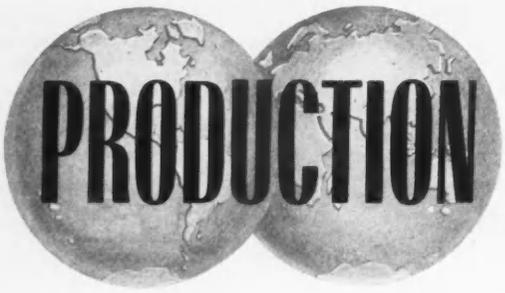

Gains Consolidated

PRODUCTION records from a number of countries throughout the world indicated a consolidation of the gains registered in principal producing areas, particularly in the Middle East, which throughout the year has been rising to points far beyond the expectation of many observers at the beginning of 1948.

With the year-end assurance that crude supplies were then more than adequate for current consumption, and announcement by some major operators that imports of oil into the U. S. from the Middle East and Venezuela were to be curtailed, it was thought that operators would level off at production rates below the peaks of 1948. But, this has not been the case universally. In Saudi Arabia, production for the first month of 1949 shows the highest rate ever attained, when a daily average of 523,882 barrels was produced. This came after the Arabian American Oil Company had reduced its runs to 466,375 barrels a day during December. The neighboring island of Bahrein also continued its high level of yield by producing at a rate of 30,458 barrels a day during January.

Kuwait, for which figures are reported through December, had a total output for the month of 6,624,623 barrels, or 213,698 barrels a day, the highest yield in its comparatively short producing history.

In Venezuela, the other principal source of crude for export, production during December averaged 1,366,666 barrels a day, bringing the total for the year to 489,971,329 barrels. During the latter part of the year, output was lifted to volumes in excess of 1,400,000 barrels daily, but with the softening of demand for the heavy fuels furnished by the crudes from the Lake Maracaibo area, is coming a substantial reduction in output. Early predictions are that over-all production from Venezuela will level out at approximately 10 percent under the peaks reached during 1948.

Egyptian Output Up

Of particular interest during December was the output of Egypt, which accounted for a daily average of 42,508 barrels, to bring its production to a new annual peak. During January the outlook for the country was considerably brightened by reports of the new Socony-Vacuum Oil Company and Anglo-Egyptian Oil Company well in the Sudr-Asl area which produced at rates approaching 40,000 barrels daily on the basis of short production tests. This one well is causing long-range planning for a new pipe line outlet to the Mediterranean which might bypass the Suez canal.

As anticipated, the production records for Canada show steady gains with November output at the rate of 42,167 barrels daily. Most of this is accounted for by the province of Alberta with its growing Leduc and Redwater fields.

December saw Germany producing 419,171 barrels, the largest production for that nation since the capitulation. This was accomplished through the drilling of 50 percent more footage during 1948 than the previous year. Economists look for a further increase for 1949.

Colombia, which seemed on the way to another record production at the beginning of last year, was hampered by strikes and political disturbances, and retarded considerably in its output for the year, but the end of the year found its fields producing at the highest rates in history. Total output for December was 2,743,800 barrels, or at the rate of 88,510 barrels a day.

Crude Oil Production

COUNTRY	COMPANY	PRODUCTION		
		Month	Barrels	Daily Average
†Bahrein	Bahrein Petroleum Co.	January	944,195	29,984
†Brasil	Conselho Nacional do Petroleo	November	14,837	495
		December	13,380	431
†Canada	All Operators	November	1,264,988	42,167
†Colombia	All Operators	December	2,743,800	88,510
Ecuador	Anglo-Ecuadoran Oil Co.	December	140,329	4,527
	Ecuador Oilfields, Ltd.	December	49,099	1,584
†Egypt	Anglo-Egyptian Oilfields	December	1,317,749	42,508
†France	All Operators	November	27,580	919
†Germany	All Operators	December	419,171	13,522
†Iraq	Iraq Petroleum Company	December	1,486,329	47,946
†Kuwait	Kuwait Oil Company	December	6,624,623	213,698
Peru	Lobitos Oilfields, Ltd.	December	203,315	6,559
†Saudi Arabia	Arabian American Oil Co.	December	14,457,619	466,375
		January	16,240,322	523,882
Trinidad	Apex (Trinidad) Oilfields	December	243,995	7,871
	Kern Trinidad Oilfields	December	37,664	1,215
	Trinidad Central Oilfields	December	49,152	1,585
	Trinidad Leaseholds, Ltd.	December	534,770	17,251
	Trinidad Pet. Dev. Co.	December	223,065	7,198
	United British Oilfields	December*	534,768	15,279
†Venezuela	All Operators	December	42,366,646	1,366,666

† Complete for country. * 5 weeks ending January 3.

Work Under Way on Pipe Line From Vado Ligure in Italy

Work on the proposed pipe line from the port of Vado Ligure to Trecate to the Ticino River has already been started, reports from Italy say. This line is being built by Societa per Azioni Raffineria Padana Olii Minerali (SARPOM), organized by the Fiat Company of Turin and the Caltex Oil Products Company, and is a project to carry Middle East crude to the site of a refinery to be built at Trecate by the same principals.

The new plant, with capacity of 10,000 barrels daily, is to be completed some time in 1950, and from its location in the area of the headwaters of the Po Valley, will be able to market its products throughout the industrial area of Northern Italy and have the benefit of water transportation to most principal points. It will also be possible to supply products to Switzerland via inland waterways. Distribution of products will be by the newly organized firm called Petrolcaltex. Installations will include a terminal station on the coast with storage capacity of about 350,000 barrels.

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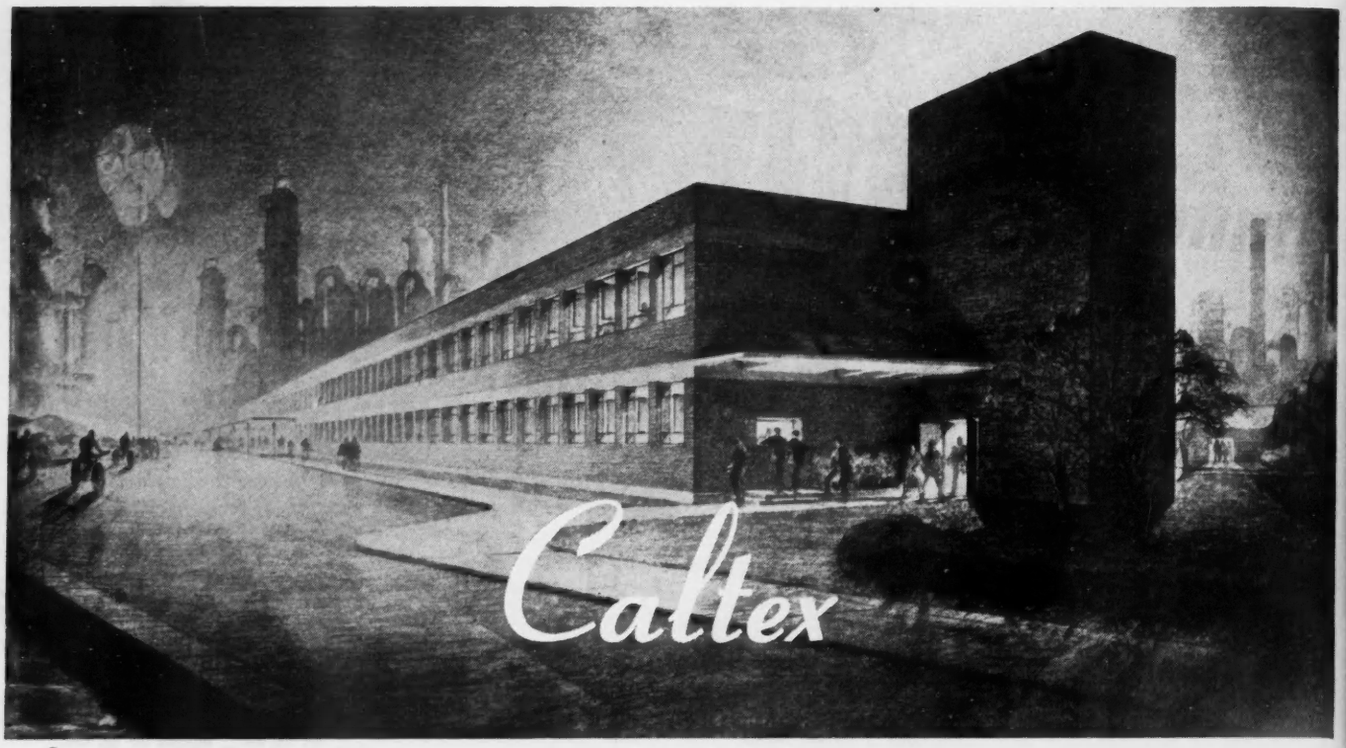

Begins European Refinery Program

In anticipation of increased European needs for petroleum products, the California Texas Oil Company (Caltex) has launched a $50 million refinery construction program in four European countries. The plants will be designed to process efficiently Middle East crude and further reduce Europe's dependence on the Western Hemisphere for refined petroleum products. The building program is already well under way in Holland and France and is projected in Italy and Spain.

In Holland Caltex Petroleum Mattschappij N. V. is now erecting a 20,000 barrel a day refinery at Pernis, a suburb of Rotterdam, on the Niewe Maas River. It is intended to fullfill demands of the Benelux countries (Belgium, Netherlands, Luxembourg), and will be completed about February, 1950. The plant is being built by Arthur G. McKee and Company. It will consist of a two-stage crude unit, a 6500-barrel a day thermal reformer, a 6400-barrel a day Dubbs thermal cracking unit, a non-selective polymerization unit of 900 barrels a day polymers capacity, a 1600 barrel a day Edeleanu SO_2 extraction plant, and necessary treating and finishing facilities. Also to be erected are a complete laboratory, workshops, and offices to accommodate a staff of 50 persons, a warehouse, cafeteria, and firehouse.

Three houses are being constructed on the refinery site for key operating personnel. Accommodations for 260 families will be arranged in a new housing project under construction in the nearby town of Vlaardingen. The refinery will employ about 350 persons.

WILLIAM SCHWARZ
heads Caltex refineries in Europe

The Pernis refinery will occupy 104 acres on soil such that all major equipment must be supported on piles varying in length from 40 to 90 feet. The entire installation will require 2500 fifteen-square-inch reinforced concrete piles. Settlement up to 18 inches is expected to occur during the first years due to soil consolidation, and as a result many difficult problems are posed in the planning of pressure water lines and sewage pipes.

Storage tanks to a maximum of 32 feet high are being supported without the use of piling. Sand pads are being placed under each tank equal to the estimated amount of consolidation—about 65 inches.

Storage facilities will be provided for approximately 1.6 million barrels of crude and products. Crude wil be received from a deepwater wharf adjacent to the site. At a second wharf barges will be loaded with products at the rate of 3500 barrels per hour.

The steam-generating plant will contain two high-pressure boilers, each capable of generating 150,000 pounds per hour at 250 pounds per square inch and

ABOVE: Administration building, Caltex Refinery, Pernis, Holland.

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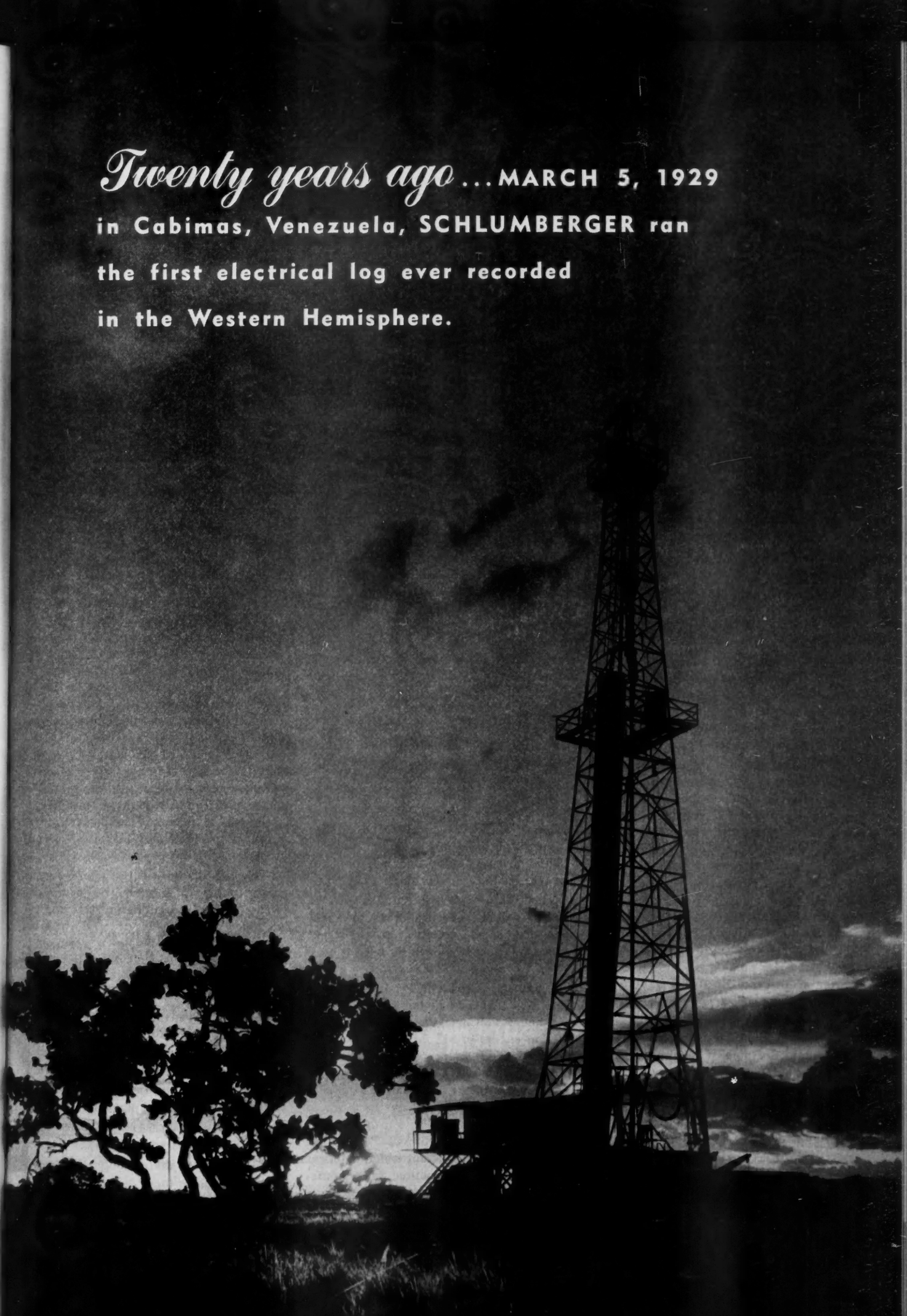

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750°F. Water from the Rotterdam municipal system is fed into the boilers after being treated by a hot lime and soda process. Air compressors in the boiler house will furnish 2000 cubic feet per minute of utility air to the refinery at 100 psi, and 1500 cfm at 50 psi for process control instruments. The thermal cracking unit steam generators will produce from waste heat an additional 45,000 pounds per hour of steam at 165 psi and 450 degrees total temperature.

A pumping station will supply 864,000 gallons of water per day for cooling. The water pump drivers are designed to operate at low pressure steam. As requirements for low pressure steam for heating purposes increase during the winter, a maximum of 3600 pounds per hour can be bled from the pump driver turbines and supplied to the refinery. During summer months, low pressure steam not used for heating will be fully utilized by the pump driver turbines. An additional pumping system will produce 2500 gallons of water per minute at 150 psi for fire protection.

The Pernis refinery will require an estimated 20 million kilowat hours of electric power per year, to be purchased from the Rotterdam system.

To help restore French economy, a Caltex affiliate, Raffineries de Petrole de la Gironde, is virtually rebuilding the Ambes plant near Bordeaux. The work, also being done by Arthur G. McKee and Company, is now a fourth finished and will be completed by early 1950.

Rebuilding of the Ambes refinery will require construction of a completely new 13,000 barrel a day atmospheric crude distillation unit and reconstruction of the war-damaged thermal reforming unit to a capacity of 3200 barrels per day. Most of the remaining refinery units are being repaired or reconstructed without changes. The plant is so designed as to permit the addition of cracking facilities at a later date.

A new pumping station utilizing many of the pre-war pumps will supply cooling water at the rate of 10,600 gallons per minute from the nearby Dordonne river.

Storage facilities suffered heavy wartime damage; only 412,000 barrel capacity remained usable or repairable. When completed, the Ambes plant will have a storage capacity of 1,350,000 barrels.

All crude for the refinery will be received and some of the products shipped from an existing public wharf. Local port authorities are constructing an additional wharf to handle the rest.

To house its 325 employes, the refinery is providing suitable facilities for workers and families. Twenty-two residences, a club house, and a cafeteria capable of serving 300 at a time are under construction.

Petroleum Claims Greatest British Dollar Expenditure

Petroleum requirements are necessitating Britain's largest single claim for dollar expenditure in 1949, according to a memorandum by the British government submitted to the European Cooperation organization. The British estimates cover the period 1949 to 1953.

British-controlled oil companies are engaged in a very complex trade, the report notes, and "their activities involve large dollar expenditure for both operating expenses and the purchase of equipment." In addition, huge quantities of oil must be purchased from American companies to meet market requirements in non-dollar areas.

The report says, "In all, British companies sold for inland consumption over 10 million metric tons of oil to the participating countries (in the Marshall Plan) in 1947. This will rise to about 13 millions in 1948 and will then constitute 40 percent of their total estimated oil supplies. These supplies are essential to the economic recovery of the participating countries; trade and industry would be most seriously dislocated if they were withheld."

Oil production and refining by British companies are being expanded, the report says, in order to reduce the need to purchase oil from dollar sources. British companies produced 46 million tons of crude in 1946 and 54 million tons in 1947, with 1948 output around 64 million tons. In 1953 the British industry should approximately double the 1947 output.

"The main contributions," the survey adds, "will come from the development of concessions held outside the dependent overseas territories, principally in the Middle East and Venezuela. Production in British Borneo and Trinidad, about 4½ million tons in 1947, is expected to increase to about 6 million tons as a result of extensions in hand.

Seven New Refineries

"An important feature of the expansion program is the development of refinery capacity. A large industry will be established within the United Kingdom capable of treating nearly 20 million tons of crude a year, compared with a throughput of 2½ million tons in 1947. Seven new refineries or major extensions will be erected in the United Kingdom at an approximate cost of $500 million. Work already has begun on three of them. This ambitious project will make a major change in the oil position of the United Kingdom. Imports of crude will increasingly replace imports of refined products and give rise to large savings in foreign exchange.

"The new plants will result in a much greater variety of products being refined for the United Kingdom and will stimulate the development of a petroleum chemical industry capable of producing many organic chemicals now imported from hard-currency sources. Refinery capacity owned by British companies outside the United Kingdom is also being increased considerably. A new refinery is now under construction in Venezuela, while increases in capacity in Holland, the Middle East and the East Indies are already under way or planned. Capacity overseas will be increased by more than 40 percent compared with 1947."

It is estimated that through 1952 more than 1 million tons of steel will be needed for plants and buildings in the British expansion program, and this amount is over and above the 2½ million tons needed for maintenance, production and marketing.

In Italy it is understood that Caltex and the Fiat motor firm are jointly forming a new refining company in North Italy. The concern will be known as Societa Anonima Raffineria Pandana Oil Minerali and will process Middle East crude shipped from the Persian Gulf to Ligino, where a pipe line will be built leading to Recate, 100 miles away.

This refinery will be the largest in Italy, with a capacity equal to about one-third of the country's total present capacity. Storage at Ligino will be provided for about 337,000 barrels of crude.

In Spain Caltex Oil Products Corporation is planning to build and operate a refinery at Cartagena. The plant will cost in excess of $15 million and will be financed about 24 percent by Caltex.

William Schwarz has been appointed general manager of all Caltex refineries for Europe and has opened an office in Paris to coordinate the European construction program. R. W. Parker has been appointed assistant chief engineer in charge of construction and maintenance; W. E. Tucker as assistant chief engineer in charge of designs; and J. W. Thomas as petroleum engineer for the company. Schwarz has served since 1944 as manager of the Ultramar SAPA refinery at Buenos Aires.

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Attempt Made to Extend Chile's Spring Hill Field

THE Chilean Corporación de Fomento de la Produccion is making an effort to extend its one commercial oil field, Cerro Manantiales (Spring Hill), on the island of Tierra del Fuego, with the idea of stepping up production to a volume of 3000 barrels a day by late summer, at which time it hopes to begin shipping oil through its pipe line and terminal.

To date 18 wells have been drilled and completed, and two important outposts are being started. No. 19 spudded during the latter part of January, and No. 20 started drilling late in February. The 18 wells drilled thus far have been in a straight line for three miles, north and south, and have served to pretty well define the producing area on what is believed to be the east flank of the structure which produces gas on the crest and oil on the flank. Oil has been found in 11 wells, and gas in five. Two were dry holes. The two wells now drilling are part of a step-out program, the first being more than a mile west of the discovery, and the other to the east of the presently producing area. The Cerro Manantiales 19 is far enough west to give definite information as to whether production will continue around the structure instead of being concentrated on the east side. The other test is seeking the eastern limits of the oil-water contact, rather critical on this side.

The field extension program is getting under way prior to the beginning of construction of the pipe line from the field to Caleta Clarencia, 50 miles southwest on the Straits of Magellan. Building of the line is scheduled to begin around July 1. The project embodies the following details:

1. A pipe line gathering system in the Cerro Manantiales field, composed of six-inch main line with four-inch connections to wells and batteries. The system is to be operated by rotary pumps driven by air-cooled engines. The installation will also entail construction of field tanks and connections.

2. A 10,000-barrel-a-day pumping system at the field, employing three portable-type pumping units consisting of 115-horsepower automotive type diesel engines, 4 to 6 by 10-inch piston-type pumps with V-belt drives.

3. A total of 42.5 miles of electric welded eight-inch main line pipe, coated with asphalt and asbestos-felt wrapping. Pipe is to be buried throughout its length.

4. Storage and loading equipment at the Caleta Clarencia terminal on Bahia Gente Grande on the northwest side of the island.

5. A Total of 3300 feet of 16-inch submarine loading line, and 3300 feet of 12-inch line, the latter for the purpose of handling ballast and bilge water from ship to shore.

Three storage tanks will be installed at Caleta Clarencia, two of 80,000-barrel and one of 55,000-barrel capacity, giving a total of 215,000 barrels capacity at the terminal. The 3300-foot length of loading lines will reach far enough to allow mooring of the largest tankers in more than 40 feet of water.

The entire project will cost an estimated $2 million, and it is expected that it will be in full operation by late in this year. After getting started on actual construction it is estimated that the main line will require about 60 days' work and another 30 days for the gathering system. The pipe is to be ditched deep enough to hold minimum temperatures at considerably less than —40° F, the congealing point for Spring Hill crude. This, together with 1000-pound pressure possibility, will be sufficient to move the crude through the line without pre-heating. If viscosity difficulties are encountered, a second pump station is to be installed midway along the line. It has been estimated that the line will have a capacity of 10,000 barrels daily at pump pressure of 250 pounds per square inch and temperature of 60 degrees, or the same volume at 500 pounds pressure and 40-degree temperature.

Spring Hill crude has a high paraffin content with a settling tendency, so heating facilities will be installed in connection with the storage tank system.

The field potential averages about 300 barrels per well per day, on the basis of preliminary tests, but the field is shut in waiting for completion of the pipe line and no sustained production tests have been possible.

Meanwhile, work may be suspended temporarily at the new San Sebastian field, 50 miles southeast of Cerro Manantiales. Two wells have been drilled, one of which was regarded as a discovery, but later reports have not been too encouraging. Operators are now waiting for full testing of the second well before deciding whether to go ahead with development.

Other plans for exploration include drilling in the Cerro Sombrero area, about ten miles south of Cerro Manantiales, where tests are planned for this year. In addition, the Corporacion plans further drilling on the Espora structure, north of Cerro Manantiales near the north coast of the island. One well was drilled to 7300 feet on this prospect last spring, but failed to find production.

Three rigs are now actively at work in Chile. Two are on the Cerro Manantiales structure, one is working on the second well at San Sebastian; and still another on the way will probably be used in a continuation of the exploratory program. Meanwhile, two seismograph crews and one gravity meter crew are working in the area, in addition to several geological parties which are maintained in the field for preliminary reconnaissance.

For the time being Chile is deferring plans for the construction of a refinery which had been tentatively planned for the Santiago area, but that project is being held in abeyance pending completion of the pipe line from Cerro Manantiales field to tide water. Chile's petroleum requirements are currently running around 18,000 barrels a day, but demand is greatly unbalanced in relation to many countries, since more than 10,000 barrels of the daily requirements are in the form of diesel oil for the operation of the nation's nitrate and copper plants upon which a substantial part of their economy is based.

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Pacific Western Deal May Alter Industry's Position

REPORTED acquisition of concession rights by Pacific Western Oil Corporation in the Saudi Arabia-Kuwait Neutral Zone is viewed in industry circles as threatening to alter the American industry's position in the Middle East. The terms are the highest ever recorded for a Middle East concession and, in the words of one foreign operator, "Open the door for the expected re-negotiation of every American contract abroad."

The agreement between Pacific Western and King Ibn Saud gives the American company—a newcomer in foreign oil ventures—full rights to Ibn Saud's one-half "undivided" interest in the neutral zone which lies between his Saudi Arabian Kingdom and the Sheikdom of Kuwait. Terms are said to include:

1. An initial payment of $9 million to $9.5 million.
2. A 55 cents a barrel royalty on production with a guaranteed minimum royalty of $1 million yearly.
3. A 25 percent participation by Ibn Saud in the new operating company to be set up.

Top officials of most of the foreign operating companies view the relatively high royalty figure as the disturbing factor in the deal. The 55 cents a barrel sum contrasts with much lower rates everywhere else. American Independent Oil Company, which received a concession last year from the Sheik of Kuwait for his undivided one-half interest in the same neutral zone, settled for 33 to 35 cents a barrel; royalty schedules in Iraq and Saudi Arabia currently run about 22 cents a barrel, and in Kuwait itself, 13 cents a barrel.

One official of an American company operating in the Middle East commenting on Pacific Western's terms, said: "We can't meet that kind of bid and I don't see how any other company can do so, either." He pointed out that royalty re-negotiations are now under way between the governments of Iraq with the Iraq Petroleum Company, and Iran with the British Anglo-Iranian Oil Company, and added: "This deal will certainly strengthen the hand of all Middle East countries in their dealings with foreign operators. Is there a possibility that Middle East petroleum operations may become so expensive that the whole Middle East program may be crippled?"

The neutral zone is a desert area, 50 by 45 miles, at the head of the Persian Gulf, south of the lush Kuwait field and north of the Saudi Arabian wells. No drilling has been in the zone yet, but American Independent has sent a geological party there for survey work. However, even if the zone proves as productive as is anticipated, operation expense would be the highest in the Middle East, with Pacific Western requiring a 2 million barrel annual production merely to pay off its royalty guarantee.

Form of the operating arrangement between Pacific Western and American Independent is not yet clear. It is believed that the two companies will have to set up a joint subsidiary operating concern for the entire zone, since apparently work cannot be divided on an area basis because of the double sovereignty of the two monarchs.

Arabian American Oil Company last year relinquished claim to rights in the neutral zone after a question was raised as to whether the company's existing contract in Saudi Arabia also covered the netural zone. At the time that Aramco surrendered all possible rights in the neutral zone, the company received from Ibn Saud confirmation that the Aramco concession contract also covered offshore oil rights in the Persian Gulf.

Pacific Western is controlled by J. Paul Getty, independent oil operator of Los Angeles, who also owns about 30 percent of Tide Water Associated Oil Company.

Although American Independent did not publicly disclose its own terms reached last year with the Sheik of Kuwait for rights in the zone, it is understood that American Independent agreed to a cash payment of $7 million, an annual rental of $600,000, and a 15 percent participation of the Sheik in the operating company. A-I's concession grant was negotiated by Ralph Davies, former head of PAW.

Royalite Oil Will Become Independent Organization

Through negotiations now in progress, one of Canada's most active companies will shortly become an independent organization. Royalite Oil Company, Ltd., is now a subsidiary of Imperial Oil, Ltd., through Imperial's ownership of approximately 90 percent of the stock, but the latter firm announced January 17 that its entire holdings would be sold to the Dominion Securities Corporation, Ltd., at $23.25 per share, and the sale will be completed as soon as a prospectus for the re-offering of Royalite shares to the public has been accepted for filing by the Ontario Securities Commission. Capitalization now consists of 717,487 no par value shares.

The sale of Imperial's holdings in the company will make it an independent organization which can further expand its operations by the exploration and development of new areas, according to Imperial representatives. Because of the extent and rapidity of oil developments in western Canada, Imperial said that normal competitive practices between Imperial and Royalite would in time lead to embarrassing difficulties for either or both of them. H. H. Hewetson, president of Imperial, said he regards the transaction as one that should be satisfactory for all concerned. He added that it will place another strong Canadian organization of competent management and trained personnel in the field of oil exploration and development and, it is expected, will attract additional capital for the development of what should prove to be one of Canada's greatest natural resources.

Imperial also said that former shareholders of Royalite who have exchanged their shares for Imperial stock since November 15, 1948, will have the right to exchange back to Royalite on the same basis. Dominion Securities Corporation will make a cash offer to buy Royalite shares held by other stockholders of the company at the same price.

A condition of the sale is that Imperial will protect the attained status of Royalite employes in pension, benefits and insurance plans and that Royalite will carry on equivalent plans. It is understood the present management of Royalite will continue to direct the affairs of the company.

Royalite obtained its Dominion charter in 1921 and until early in 1948 concentrated its exploration and development largely in southern Alberta, particularly in Turner Valley, where it is the largest single holder of property. According to a report by James Richardon & Sons, the company on April 1, 1948, owned or had an interest in 65 oil producers, 60 wells producing gas and distillate, and a direct interest in 13 other crude oil and 6 gas wells. It holds approximately 90,000 acres of exploratory leases outside of the Turner Valley field.

The company also owns two big absorption plants in the Turner Valley field in addition to a large gas scrubbing plant, and through subsidiaries operates pipe lines from Turner Valley to Calgary, and a natural gas distribution system.

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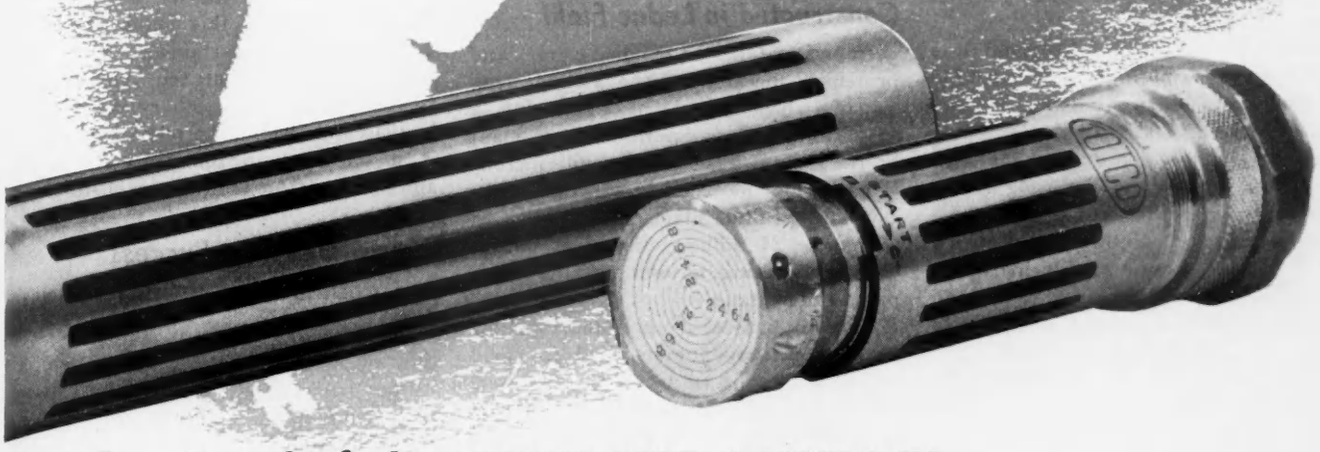

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RECENTLY A CHECK of every drilling area in South America disclosed the fact that TOTCO RECORDERS are used by 95% of the operating companies and drilling contractors! What a testimonial to the value of TOTCO RECORDERS and Controlled Vertical Drilling methods for drilling oil wells faster, cheaper and more efficiently.

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Phillips Makes Discovery Near Venezuela's San Joaquin Fields

Phillips Venezuelan Oil Company is the latest organization to report a new discovery in Venezuela. Holder of a 130,000-acre block of exploration concessions west and northwest of the San Joaquin group of fields in eastern Venezuela, the firm has been doing geological work and actual wildcat drilling for more than two years. The first discovery on this acreage was reported during January, when the wildcat found saturated sand in the Oficina formation, in the zone equivalent to the "Colorado" of the San Joaquin group.

A total of 165 feet of net sand was logged in the Colorado between 7740 and 8500 feet, and preliminary production tests have been made on three of the sands in the zone. On the first test of the upper sand the well flowed 40-gravity oil at the rate of 1500 barrels daily through a three-eighths-inch choke from a section which had been perforated for only 15 feet.

On later tests of three successively deeper sands it flowed at rates of 500, 300 and 500 barrels daily, respectively, all tests having been made through small chokes. Final completion is planned as a dual-zone producer from the two top sands.

The company has plans for rapid development of the new area and has sent additional drilling equipment to the area. Plans are also under way for providing an outlet for the oil. Currently it is thought that the arrangements will be made to connect the new field to either of two major pipe line trunk systems now passing a number of miles eastward on the way to the terminals in the Puerto la Cruz area. One of the trunk systems is operated by Mene Grande Oil Company, the other by Socony-Vacuum Oil Company of Venezuela.

The new strike marks the second commercial find by Phillips, a comparative newcomer to Venezuela operations. The Mata Grande field was found in 1946, about 70 miles eastward from this new find, which has been tentatively named the B-1 Field.

With discovery of this new field, the importance of the immediate area is still further enhanced. During recent months Creole Petroleum Corporation and Pantepec Oil Company have succeeded in finding important production in the El Roble field from the Merecure formation which underlies the Oficina. All wells to this formation have proved prolific producers, and in addition the field has been enlarged considerably by the recent drilling.

Slightly more than a year ago Mene Grande found a new field at Toco, west of the original group, and has placed two rigs in active exploitation of that field. It has shown itself capable of producing at rates of 750 barrels daily per well from the few wells drilled to this time.

Gas Processing Plant to Be Constructed in Leduc Field

Imperial Oil, Ltd., discoverer and principal operator in the Leduc field, Canada, has completed plans for a $6½ million gas processing plant in the field. The system will include a gathering network, compressor station and gasoline plant, and is designed to handle 24 million cubic feet of gas daily, recovering natural gasoline, propane and butane.

Equipment is also on order to allow the residue gas not required for field operations to be returned to the reservoir, or to be distributed for domestic and industrial use as fuel. With such arrangements, no appreciable volume of gas should be flared after completion of construction. Work is to get under way this spring, and if materials are delivered on schedule, the plant should be ready to operate by mid-summer of 1950. Contract for construction has been let to C. F. Braun & Company, who designed and engineered the project.

The results of experiments now under way in the field will determine how much of the gas will be returned to the reservoir. The company has already installed two compressors at Leduc with which experiments are being conducted on gas injection into the D2 and D3 zones of the Devonian pay horizon. From the results of engineering studies it appears that the D2 zone has gas in solution with oil as the main reservoir energy and it may not be feasible to inject gas. The D3 zone has energy from a gas cap and from bottom-hole water, and it is definitely planned to attempt to maintain the gas cap in this zone. Currently there is no commercial market for gas produced in connection with the production of crude in the Leduc field, and all of the excess other than the comparatively small amount used in field operations, is being flared.

Recovery of liquid products from Leduc casinghead gas will be on the order of 1¼ gallons per thousand cubic feet of gas, about one-half of the liquid recovery being natural gasoline and the remainder butane and propane.

Aerial Exploration Survey To Be Undertaken in Iran

Large areas of Iran are scheduled for an immediate aerial exploration survey through a program instituted by Anglo-Iranian Oil Company. Under prevailing conditions it is estimated that the survey expedition will remain in the field for about six months out of each year, completing the current survey in two to three years.

The investigation of petroleum possibilities from the air is not new to Iranian operation, this being the sixth such survey undertaken. The first three were more than ten years ago in 1936-37-38, and two others were made in 1946 and 1947. The plane being used is a modified medium-duty freighter, and will carry a crew of seven men.

Sunray Has First Success In Canadian Operations

Sunray Oil Company, subsidiary of Sunray Oil Corporation, has registered its first success in Canadian operations with completion of Sunray-Pacific-Redwater 1, in the new Redwater field northeast of Edmonton. This test was drilled as a half-mile stepout and proved up an expensive quarter-section for which a bonus of $283,000 had been paid for a Crown lease.

Total depth is 3385 feet in Devonian D3 pay and casing had been set at 3241 feet. The completion was made after treatment with 3000 gallons of acid and kicked off with an initial flow of 1700 barrels in 27½ hours before being closed in for lack of additional storage. It has been assigned a potential of 1480 barrels a day.

New Plan Would Put Italian Activity Under One Company

A bill is expected to be introduced into the Italian Parliament within two or three months asking that all drilling, exploration and exploitation for oil and gas in Italy shall be under the direction of the Azienda Generale Italiana Petroli, the government-controlled oil company.

The proposal is sponsored by the Italian Ministry for Industry and Commerce, which is urging as a first step that the government grant the AGIP credits of a billion lire for the purchase of drilling and production equipment.

NEW AND IMPROVED Equipment SUPPLEMENTING COMPOSITE CATALOG

New and improved equipment of manufacturers who describe their products or services in the current Composite Catalog

80—Electric Paving Breaker

This item supplements Homelite Corporation data as shown on pages 1736-1737 of Composite Catalog.

Operated by electricity rather than by compressed air, a new 84-pound high-cycle paving breaker is powered by a 129-pound dual-voltage gasoline-engine-driven generator, which can be used for operating other types of high-cycle tools as well as standard 110-volt tools and floodlights.

Both breaker and generator make a

compact combination that can fit in the trunk of a car and can be put into operation by one man.

This new breaker is unaffected by dust or abrasive particles. The motor has no brushes or commutator to wear out. There is no electrical connection between rotor and stator and sealed ball bearings support the rotor shaft. A floating cylinder prevents the transmission of shock to the driving mechanism. A positive plunger pump lubricator has an automatic switch which stops the breaker when its oil reservoir is empty.

For additional information write Homelite Corporation, Riverdale and Nelson Streets, Port Chester, N. Y., *referring to* World Oil *item* 80.

81—Reciprocating Pumps

This item supplements Frank Wheatley Pump and Valve Manufacturer data as shown on pages 4285-4304 of Composite Catalog.

Series 1800 duplex reciprocating pumps come in sizes from 2½ inches to 4 inches by 6 inches. They are V-belt driven and can pump 162 barrels per hour at 350 pounds per square inch, running at 90 revolutions per minute.

This new pump line is particularly adapted to partially abandoned properties where only one or two wells are still pumping. Centralized pumping stations can be dismantled and individual 1800 series pumps placed on the still-producing wells.

Another new pump series, featuring round valve pots for higher pressures and volumes, is the series 6000. This line comes in 2¼ inches to 5 inches by 10 inches, and 4-inch to 7-inch by 10-inch sizes, V-belt driven. With semi-steel fluid end, 1920 pounds working pressure is possible, using the two and three-eighths-inch liners.

For additional information write Frank Wheatley Pump and Valve Manufacturer, Hale Station, Sand Springs Road, Tulsa 6, *referring to* World Oil *item* 81.

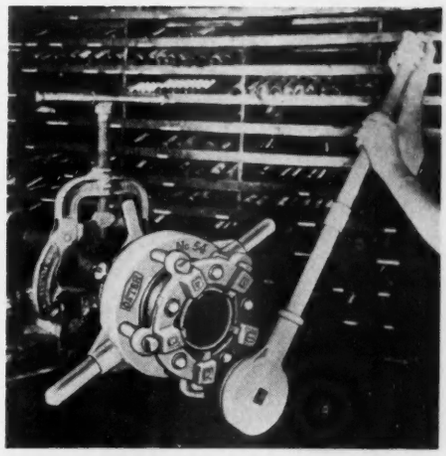
82—Pipe Threading Tool

This item supplements The Oster Manufacturing Company data as shown on page 3261 of Composite Catalog.

A new pipe threading tool is strongly built to withstand the strain when used with drive shaft for power operation with a portable pipe machine. For hand operation the tool is used with a ratchet handle.

Identified as "The Leader—No. 54," this geared receding die-stock has a drive gear with tensile strength of 40,000 to 60,000 pounds per square inch. The steel pinion runs in needle bearings and is supported by a tubular steel housing. Pinion has machine cut teeth and is completely hooded.

The complete tool is furnished with four individual sets of dies, each set having five individual and replaceable



segments. Each set of dies threads one pipe size only. The four standard pipe sizes are 2½, 3, 3½, and 4-inch. Die holder is a separate unit and is replaceable at nominal cost. This holder is adjustable to permit cutting oversize and undersize threads.

The lead screw is designed to prevent jamming when power-driven by an inexperienced operator. The universal chuck has three fully serrated jaws with square head locking screw. Graduations on pinion shaft housing indicate correct length of thread to be cut.

Lifting handles are carefully balanced at center of gravity so the tools can be readily placed in position on the pipe.

Design of gear body hood permits easy backing off of the tool when the dies recede slightly from the cutting position. This prevents the dies from binding or cutting as the tool is retracted and also helps to avoid chipping the teeth on the dies.

For additional information write The Oster Manufacturing Company, 2057 East 61st Street, Cleveland 3, Ohio, *referring to* World Oil *item* 82.

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SUPPLEMENTING COMPOSITE CATALOG

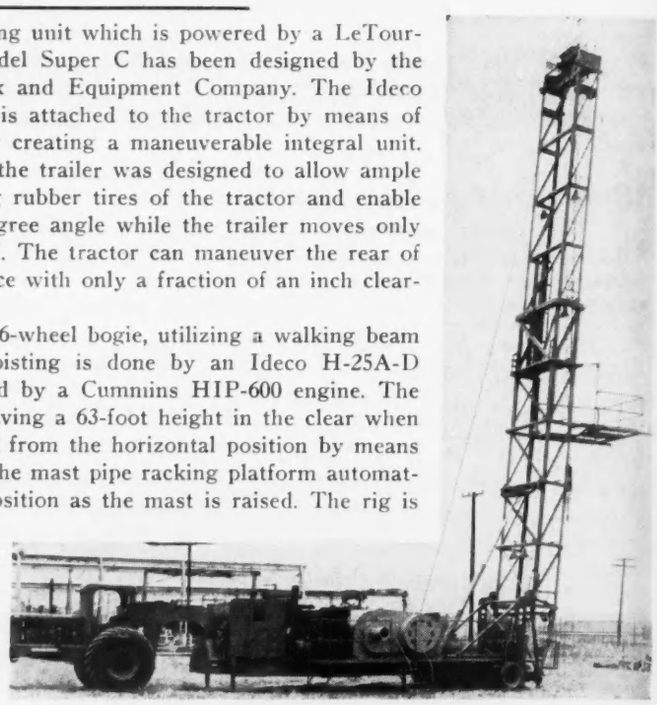
83—Tractor-Powered Hoist and Mast

This item supplements R. G. LeTourneau, Inc., data as shown on pages 2270-2271 of Composite Catalog.

An oil well servicing unit which is powered by a LeTourneau Tournapull model Super C has been designed by the International Derrick and Equipment Company. The Ideco Rambler Big trailer is attached to the tractor by means of a gooseneck, thereby creating a maneuverable integral unit.

The gooseneck of the trailer was designed to allow ample clearance for the big rubber tires of the tractor and enable it to assume a 90-degree angle while the trailer moves only a few inches forward. The tractor can maneuver the rear of the trailer into a space with only a fraction of an inch clearance.

The trailer has a 16-wheel bogie, utilizing a walking beam construction. The hoisting is done by an Ideco H-25A-D Hydrair unit powered by a Cummins HIP-600 engine. The mast is telescopic, having a 63-foot height in the clear when extended. It is raised from the horizontal position by means of a hydraulic run. The mast pipe racking platform automatically extends into position as the mast is raised. The rig is equipped with two screw jacks instead of the customary four and has a deadline spooling drum between the lower members of the frame. Another innovation consists of the use of a hydraulic motor for extending the telescopic section.



The cab on the trailer extension will shelter six workmen from inclement weather.

For additional information write R. G. LeTourneau, Inc., 2305 North Adams, Peoria, Ill., *referring to* WORLD OIL *item* 83.

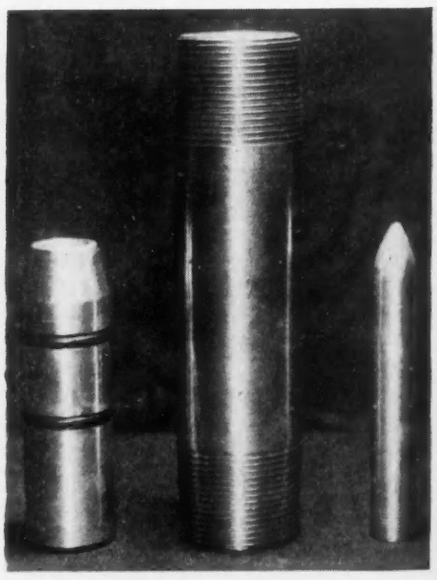
84—Tubing Seal

This item supplements Houston Oil Field Material Company, Inc., data as shown on pages 1777-1800 of Composite Catalog.

The HOMCO-Jones tubing seal, made of soluble magnesium material, permits the running of a dry string of tubing, thus allowing drill stem testing and eliminating swabbing in completing a well. The initial action is started by go-deviling or dumping acid to the top of the plug. In a short while, the acid has opened the quarter-inch bore of the plug, thus converting it to a bottom hole choke. After several days, the tubing seal is completely eroded away by the action of the well fluid.

In running, the tubing seal is inserted into a seating nipple just above the mud or gas anchor. Depending upon well conditions, a packer may or may not be used with the installation. After reaching bottom with the tubing, and setting the packer, if one has been used, a dump bailer or a breakable go-devil has spotted acid on top of the plug. After a short space of time the fluids begin entering the top through the choke.

For additional information write Houston Oil Field Material Company, Inc., P. O. Drawer 2589, Houston 1, *referring to* WORLD OIL *item* 84.



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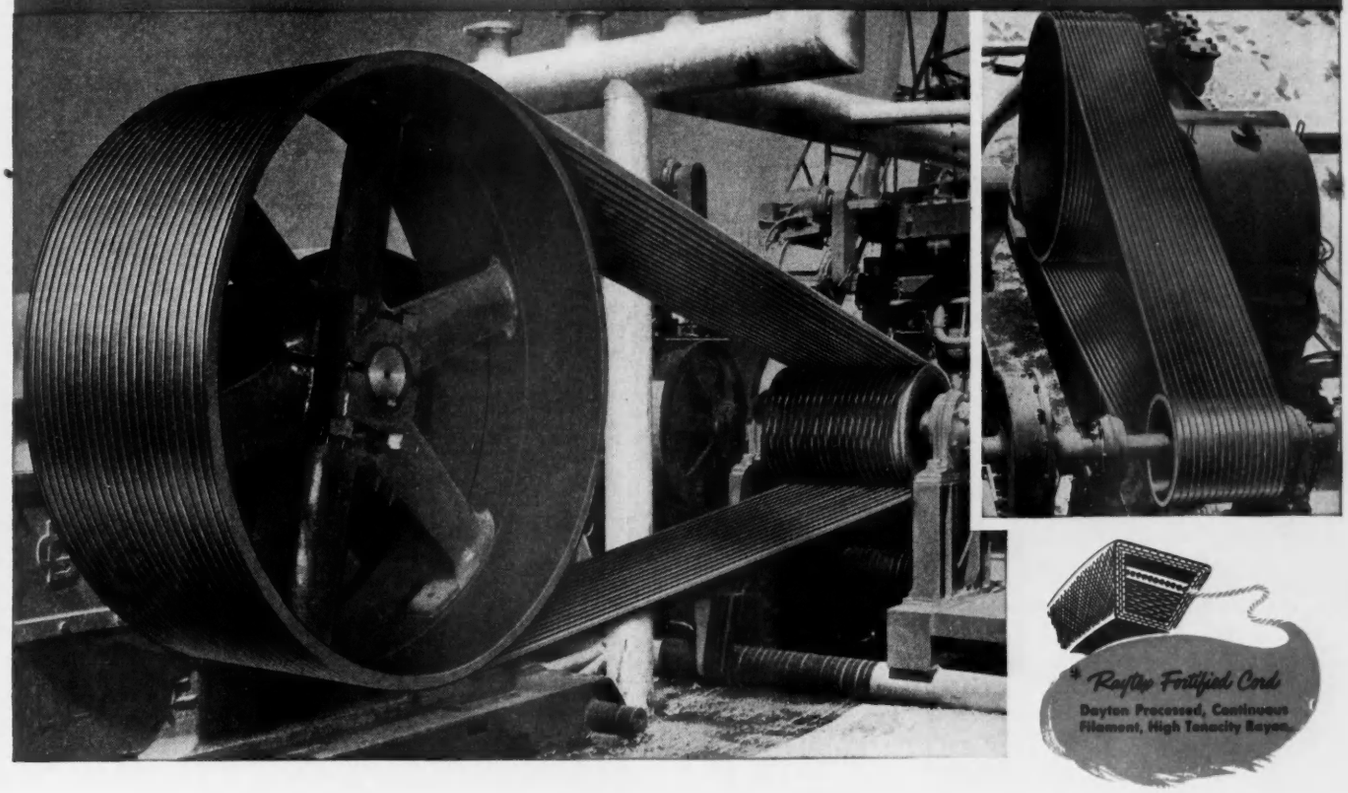

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Standardize on Dayton Rayon Cord V-Belts for your toughest oil field jobs. They'll prove themselves quickly . . . deliver unequaled performance day after day, month after month . . . regardless of wind or rain, dirt or dust, high or low temperatures, oil or grease. They're built tough for tough service!

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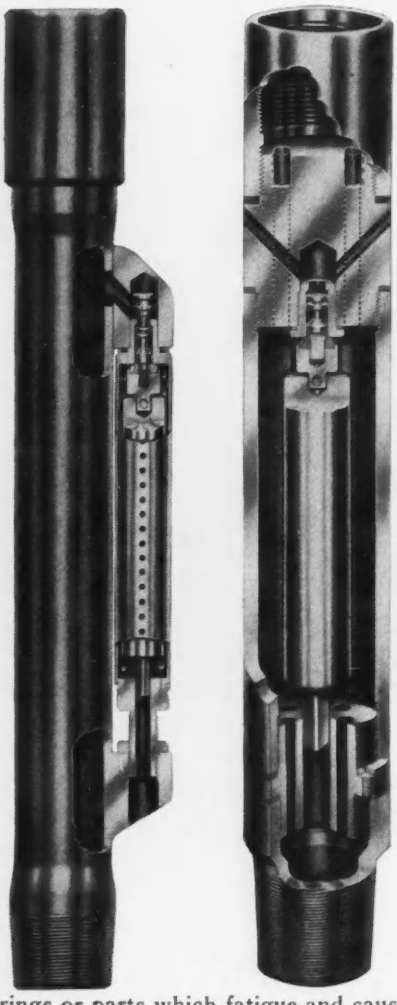
85—Gas Lift Valve

This item supplements Wilson Supply Company data as shown on pages 4377-4382 of Composite Catalog.

To complete the line of Nixon gas lift equipment, "weight loaded" gas lift flow valves have been developed for producing medium and high fluid wells.

The new gas lift valves have no springs or parts which fatigue and cause shutdown time in production. The opening and closing actions of the valves are controlled by a solid steel weight attached to a small loose fitting piston. Once set, the valves remain in calibration throughout their life as the temperature changes.



There are only three wearing parts to the valve. These parts can be replaced by the operator and do not require returning to shop for reworking or pressure chamber testing.

Total volume of fluid to be produced determines the type of valve to use. Wire line-intermittent flow valves, tubing valves for medium producing wells, and casing flow valves for lifting extremely large amounts of fluid are available.

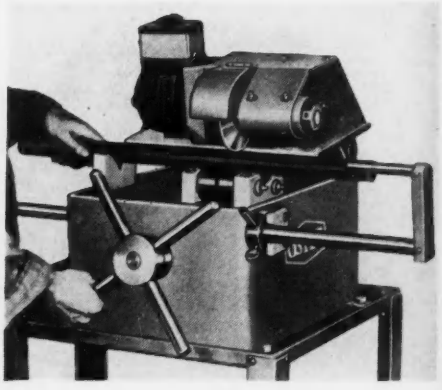
For additional information, write Wilson Supply Company, 1412 Maury Street, Houston, *referring to* WORLD OIL *item* 85.

86—Pipe Cutting Off Machine

This item supplements The Oster Manufacturing Company data as shown on page 3261 of Composite Catalog.

A new machine, known as the No. 662 "Cut Master," is designed for cutting off small or large quantities of pipe within the range of one-fourth inch to two inches, inclusive.

The one-half horsepower, variable speed motor is the geared head type for light socket operation. The motor, idler shaft and cutter shaft are mounted as a unit on a plate hinged to the base casting. As the hand wheel is turned, the cutter wheel is moved up or down. A feed screw mechanism simplifies operation.



Rollers supporting the pipe to be cut off are mounted on needle bearings to minimize friction, permitting the pipe to turn freely. Rollers are grooved to prevent breakage of the cutter wheel, which is ground to reduce burr on pipe. What burr remains is removed by chamfer on dies.

For additional information write The Oster Manufacturing Company, 2057 East 61st Street, Cleveland 3, *referring to* WORLD OIL *item* 86.

87—Rotary

This item supplements The Brewster Company, Inc., data as shown on pages 717-748 of Composite Catalog.

Built to be as short and compact as possible, the OB-12-S model rotary is 29 inches from center line of table to center line of sprocket. The OB-12-L model has an extended pinion shaft with a dimension of 44 inches center to center.

The rotary table is supported by a

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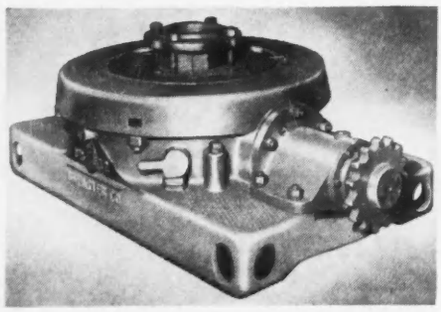
large angular contact ball bearing operating in an oil bath. All rotating loads are carried on this bearing. All up-thrust loads are placed on an extra large bronze bushing, thereby greatly increasing the life of the table bearings. No bearing adjustments are required, since the table bearing automatically seats itself according to the load. Pinion shaft bearings are Timken Two-Row tapered non-adjustable bearings which require only lubrication.

Three separated oil reservoirs provide positive, continuous lubrication for the table bearing, the gears, and the pinion shaft bearings. The rotary table is made slush-proof by labyrinth grease seals equipped with Alemite fittings.



Beds and skids of the OB-12 rotaries are cast integral from alloy steel. Ring and pinion gears are heat treated. Table locks engage table skirts to remove shock loads from ring gear, pinion and bearings.

For additional information, write The Brewster Company, Inc., Shreveport, *referring to* WORLD OIL *item* 87.

88—Tool Chest

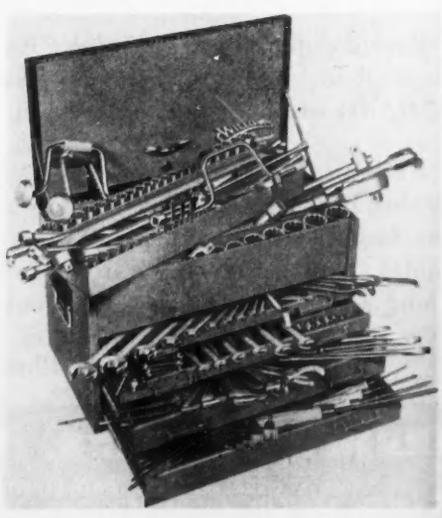
This item supplements J. A. Williams & Company data as shown on pages 4310-4311 of Composite Catalog.

The "Superchest" No. 2001 tool chest contains a combination of sockets and attachments in ¼, ⅜, ½ and ¾-inch drives, wrenches, pliers, chisels, screwdrivers, etc., totaling 146 pieces in all. Each tool has been selected to cover a wide range of work from ignition and electronics to truck, bus and industrial applications.

The chest is constructed of heavy gauge steel reinforced and welded. Drawers with handy compartments operate on free-acting suspension slides. A removable tray gives access to the interior and has compartments which keep sockets at proper height within finger-tip reach. A cylinder lock on the hinged front panel locks the entire chest.

In addition to the chest, the new Williams line consists of 35 matched assortments of various types and sizes of tools with openings from three-sixteenth inch to 2⅜ inches.

For additional information write J. H. Williams & Company, 400 Vulcan Street, Buffalo 7, N. Y. *referring to* WORLD OIL *item* 88.



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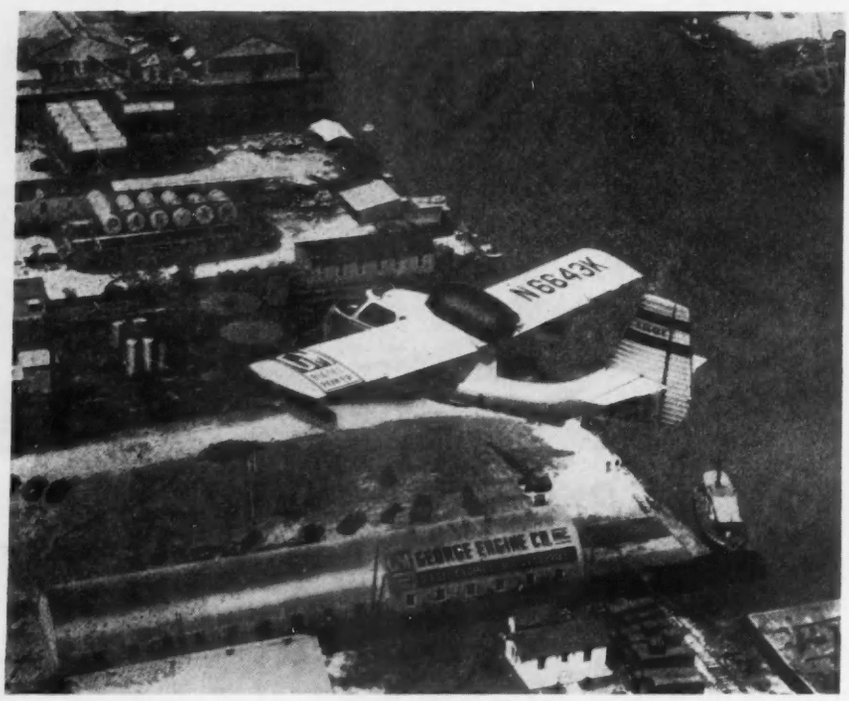

● We are proud of our new Republic Seabee Seaplane, which is constantly alerted to answer your calls for service on G. M. Diesel-powered boats and rigs. Now, there's no need to suffer serious delays and shutdowns due to missing or broken parts. Give us a call, and we will literally come flying, bringing parts and mechanics to straighten out your trouble. No location is too remote or inaccessible for our flying "trouble-wagon."

● In a further effort to round out our service we have opened two new branches. The one at 630 Destrehan Avenue, on the Harvey Canal, has a canal-side dock where you can tie up. The other, in the aircraft hangar at Grande Isle, is maintained with a particular view to the convenience of operators in that vicinity.

● All of our shops are completely outfitted to service and rebuild G. M. engines. Each is fully staffed with mechanics and completely stocked with parts, and operated on a 24-hour basis.

"Round the Clock Parts and Service"

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1111 Jefferson Highway, P. O. Box 10054
630 Destrehan Avenue (on Harvey Canal) **NEW ORLEANS 21, LA.**

Lake Charles Branch—718 Front Street

BRANCHES AT: — HOUMA — BERWICK — GRANDE ISLE

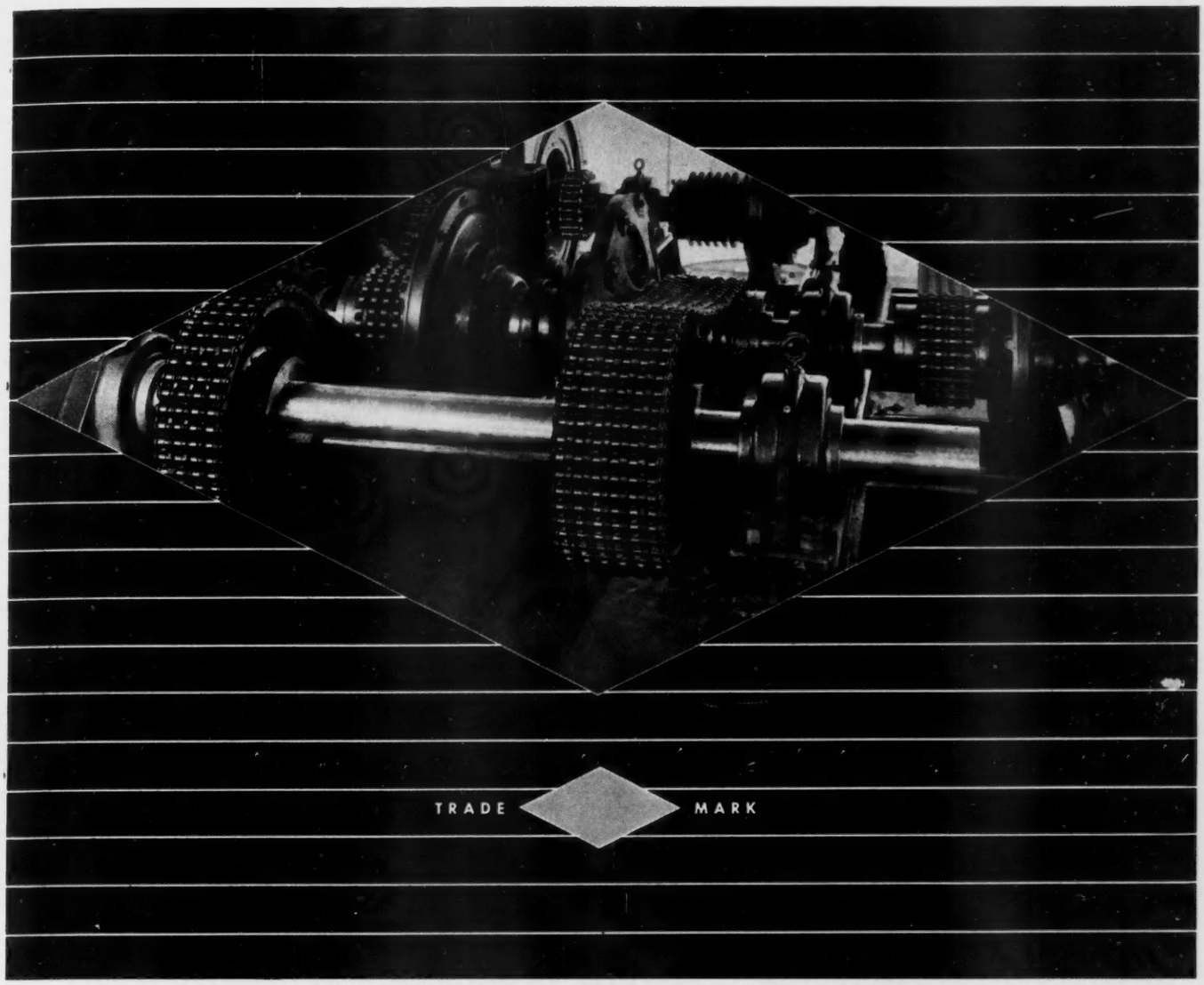


Illustration shows both Diamond Roller Chain Drives and Diamond Flexible Couplings.

The "Diamond" is Your Guarantee of Unvarying Quality

• Through nearly sixty years of continuous Roller Chain manufacture, the Diamond trademark has meant one unvarying standard of quality—the mark of excellence, reliability and integrity.

Preferred by so large a majority of America's leading builders and users of machinery and equipment, Diamond Roller Chain Drives insure maximum performance efficiency and long-life dependability.

DIAMOND ROLLER CHAIN DRIVES

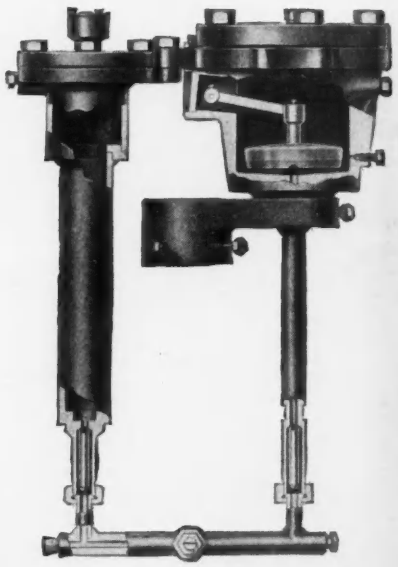
Diamond Chain Company, Inc. Indianapolis 7, Indiana

OTHER NEW AND IMPROVED *Equipment*

89—Mercury Manometer

A new type of mercury manometer has been built to meet industry's requirements of positive actuation, dependable performance and greater adaptability in flow, liquid level and differential pressure measurement. The manometer is designated as Model 1500 to signify its 1500 pounds per square inch working pressure and is available in ranges of ten to 400 inches of water. It is built for use on indicating, recording or controling instruments and two manometers can be mounted on a single case for recording two flows or ratio flow controls.

Features include: (1) Greater energy output made possible by the use of a large diameter float travel; (2) specially designed pressure tight bearing of stainless steel with Teflon bearing surfaces; (3) positive overrange protection is provided with positive-acting, non-sticking check valves, submerged in mercury.



These valves give protection against loss of mercury from overrange, sudden fluctuations and flow reversal; (4) leakless damping adjustment under full-rated pressure is assured with an uniquely designed damping device; (5) interchangeable range chambers contribute greatly to the adaptability of the new manometer which now gives continuous ranges from ten to 533 inches of water. No piping changes are necessary when changing from one range to another.

For additional information write for Bulletin 98182, Taylor Instrument Companies, 38 Ames Street, Rochester 1, N. Y., *referring to* WORLD OIL *item* 89.

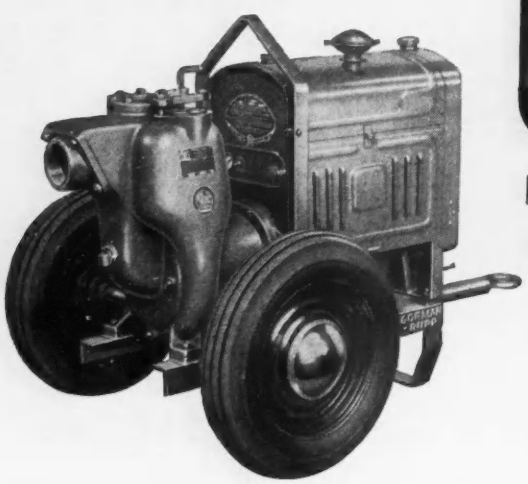
90—Extrulite Core Tubes

Extrulite Core Tubes are especially designed for handling and storing of oil well cores. Tubes of specially-made clear, oil, gas, and waterproof plastic are supplied in any specified length. They are made in diameters from one to three inches, in one-fourth inch increments. A special tube 1⅜-inch diameter by seven inches is supplied for side wall cores. This size is being furnished in large quantities to companies operating coring service, as well as the oil companies.

Extrulite Core Tubes are closed at each end with specially fabricated plastic caps. One cap is applied at the factory and made a permanent part of the tube by a special solvent compounded for this service. The second cap is a snug fit, furnished with the tube, to be sealed by the operator. Solvent, in bottles with a brush applicator, is supplied so that operators can seal their own containers. When sealed, the tube becomes an air, water, gas and oil tight container that must be cut to "get at" contents. The container is transparent; therefore, a tag inserted before sealing can be read from the outside. Thus the tag cannot be lost from the tube.

For additional information, write Extruders, Inc., 8509 Higuera Street, Culver City, Calif., *referring to* WORLD OIL *item* 90.

NEW.... Complete Line of Gorman-Rupp Heavy Duty Pumps



Challenging Any Pump, Size for Size to

PRIME AS QUICK
PRIME AS HIGH
PUMP MORE DIRTY WATER
MATCH PERFORMANCE

Gorman-Rupp Self-Priming Centrifugal Pumps have long led the field in dependability and performance. NOW! Gorman-Rupp goes further ahead with its new line of Heavy Duty Pumps.

Streamlined inside, where streamlining counts, they are the quickest priming, fastest pumping, never-quit pumps available.

For instance -- the new Model 40M 4" pump primes at 20 ft. suction in just 33 seconds; 30 ft. suction in 67 seconds (sea level).

Gorman-Rupp's challenge is not idle talk. Our distributors will put a pump on the job alongside any other make, size for size. Unless our pump proves to be the best all around pump, its return will be accepted and the user paid for any installation expense incurred.

MID CONTINENT OIL FIELD REPRESENTATIVE
TOM L. TURNER
1335 MELLIE ESPERSON BLDG., HOUSTON 2, TEXAS

THE GORMAN-RUPP COMPANY
MANSFIELD, OHIO

PROTECTION

against "freezing-up" and disrupted service

PARKERSBURG INDIRECT HEATERS

have these exclusive advantages:

1. High pressure coil inlet with swaged section for use of Parkersburg Immersed adjustable choke.
2. High pressure heating coil outlet.
3. Streamlined helical seamless steel heating coil.
4. Heavy wall burner tube assembly.
5. Self mixing burner heads.
6. Self mixing pilot burner heads.
7. Fuel gas piping manifold.
8. Pilot gas piping manifold.
9. Stack with down draft diverter, guy lugs and damper.

With Parkersburg Indirect Horizontal Heaters "on the job" you can rest easy about the flow of your high pressure gas wells. Control and separation equipment can't freeze-up because Parkersburg Heaters supply sufficient heat to the system to prevent the freezing of connate water vapors in the gas stream.

The exclusive design, featuring efficiency and simplicity have been proved by scores of installations, operating under all types of weather and pressure conditions.

Ask your nearest Parkersburg Representative for facts and details about the Heater for your high pressure gas wells.

4902

THE PARKERSBURG RIG & REEL CO.

PARKERSBURG & OCS PRODUCTS

GENERAL OFFICES, PARKERSBURG, W. VA.
Plants at Parkersburg, W. Va., Coffeyville, Kan., Houston, Texas
District Offices
Dallas - Houston - Los Angeles - Tulsa - New York

OCS

PARKERSBURG

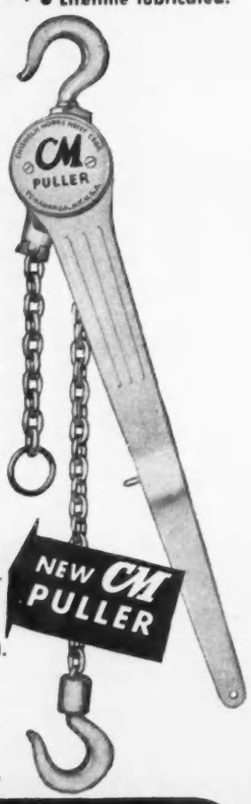
WHY BUY LESS

...the best costs so little

CM HOISTS AND PULLERS are ruggedly constructed to give you years of trouble-free service. Yet they are unusually light... easy to handle because they are constructed of the strongest alloys of steel and aluminum. Equipped with famous Herc-Alloy flexible, welded alloy steel chain.

- Capacities from ¼ to 10 ton.
- 1-ton model weighs only 35 pounds.
- 96% efficient—easy to operate.
- Lifetime lubricated.

NEW CM CYCLONE



- Capacities ¾, 1½, 3 and 6 ton.
- ¾-ton model weighs only 13 lbs.
- Lifts or pulls at any angle.
- Lifetime lubricated.

NEW CM PULLER

Write for catalog and name of your nearest CM dealer.

CHISHOLM-MOORE HOIST CORPORATION

Affiliated with Columbus McKinnon Chain Corp.

GENERAL OFFICES AND FACTORIES: TONAWANDA, N. Y.

SALES OFFICES: New York • Chicago • Cleveland San Francisco • Los Angeles

OTHER NEW EQUIPMENT

91—Truck Tracks

To beat winter snow and mud, truck operators may now fit their hauling equipment with crawler-type tracks. These conversion units, known as "Truck Tracks," were formerly channeled to the armed forces. This winter they will be available to private operators everywhere.

Designed to add tractor performance to conventional single and tandem axle trucks, Truck Tracks were tested and approved by Army engineers. They permit effective hauling operations under mud, snow and desert conditions which stall ordinary wheeled vehicles.

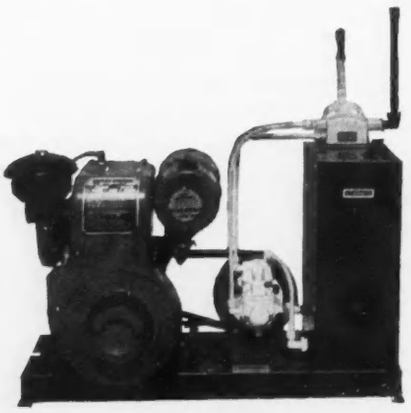
The tracks may be fitted to single or tandem axle trucks equipped with most standard dual tires. Mounting the tracks is a simple operation which takes the driver about ten minutes. Even less time is required for removal.

Pads are made of drop-forged steel alloy. Fitting is done by adding or removing pads and linkage. Every pad has a master adjustment to assure proper track tension. Connecting the pads is a cadmium-plated chain of heat-treated, high tensile steel.

For additional information write P & G Supply Company, 615 S. E. Market Street, Portland 14, Ore., *referring to* WORLD OIL *item* 91.

92—Hydraulic Power Unit

An hydraulic power unit for pipe straightening machines is designed to speed up pipe straightening by eliminating hand pumping. Requiring only one connection for installation, the hydraulic



power unit incorporates many safety devices and all moving parts are away from the operator. Models are available from 2000 to 6000 pounds per square inch. This unit also can be used to power hydraulic presses or other hydraulic equipment.

For additional information write G. T. Bynum Company, 1008 North Peoria, Tulsa, *referring to* WORLD OIL *item* 92.

DIAMOND CORING

brings...

✓ SPEEDIER PENETRATION

and...

✓ GREATER RECOVERIES

✓ DIAMOND CORE BITS ...for sale

✓ SPECIAL CORE BARRELS for rent or sale

✓ SERVICE ENGINEERS

DIAMOND OIL WELL DRILLING COMPANY

MIDLAND, TEXAS
815 MIDLAND TOWER PHONE 2710

OKLAHOMA CITY, OKLA.
PHONE 62-1538

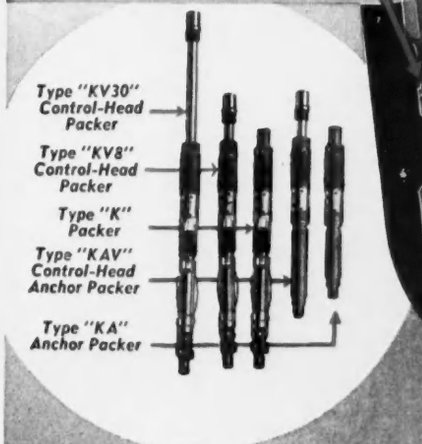
DOUBLE-SEALED

PROTECTION WITH *Guiberson* TYPE "KV" PACKERS

Built for trouble-free performance in deep wells where high pressures and high temperatures are encountered. Guiberson's Type "KV" Packers have double-sealed protection at the valve—the regular tapered metal valve and seat plus a special multi-ring resilient sealing sleeve. The pack-off rubber is oil-resistant, has reinforced ends, and will not vulcanize to the casing. Dovetailed slips are extra large, heat-treated. Heavy seamless mandrel has full opening —internal diameter is same as tubing string. Ample by-pass area permits faster running and pulling in heavy fluid. Valve is locked in open position by rugged gudgeon assembly to prevent closing when running in the hole.

Guiberson "KV" Packers pull with ease. The 30" valve lift on the "KV30" permits a long stroke to dislodge the slips and packing rubber. Type "KV" packers will pull loose easily even with a high head of fluid above the packer, due to the small valve diameter.

Guiberson Type "KV" Packers are ruggedly built of durable materials to give you positive pack-off under the most difficult well conditions. Available in 4¾" to 7⅝" casing sizes. See the Composite Catalog, pages 1508-11, for the complete series of "K" Packers in Hook-wall or Anchor types with or without valve.


Type "KV30" Control-Head Packer
Type "KV8" Control-Head Packer
Type "K" Packer
Type "KAV" Control-Head Anchor Packer
Type "KA" Anchor Packer

SAFE THAN SORRY BETTER BE — GUIBERSON (REG. U. S. PAT. OFF.)

Guiberson U.S.A.

THE GUIBERSON CORPORATION

DALLAS, TEXAS — Established 1919

CALIFORNIA DISTRIBUTOR: The W. R. Guiberson Co., 717 East Gage Avenue, Los Angeles 1, Calif.

EXPORT OFFICE: 30 Rockefeller Plaza, New York 20, N. Y.

BRANCH OFFICES IN Oklahoma City, Okla.; Tulsa, Okla.; Longview, Texas; Kilgore, Texas; Alice, Texas; Houston, Texas; Odessa, Texas; Wichita Falls, Texas; Lafayette, La.; Wichita, Kansas; Newark, Ohio.

© 1948, The Guiberson Corp.

93—Oil Field Truck

Designed specfically for hauling tremendous loads off-the-road, the LRSW has a gross-vehicle-weight rating of 115,000 pounds and a wheelbase of 247-62 inches. The frame is electrically fused into a single massive piece. Huge alloy steel I-beam side-members are reinforced and joined by five cross-members.

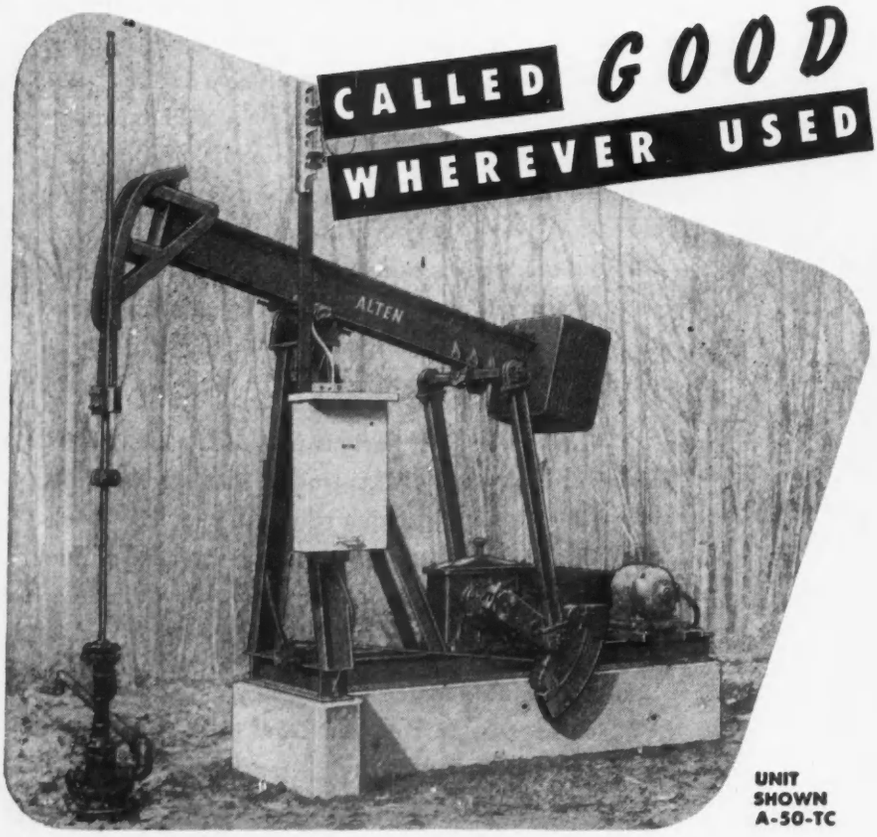
Power for the huge truck is supplied by a 275 horse power Cummins Model NHBS diesel engine. A two-plate air-assist clutch relieves driver fatigue and puts the engine to work through a massive five-speed Mack transmission and a three-speed Brown-Lipe auxiliary. This combination of main and auxiliary transmissions provides a total of 15 forward speeds. A tower type power take-off, which drives the winch, mounts directly on the auxiliary box.

The Balanced Bogie eliminates wheel fight, tire scuffing and consequent power loss. Two sets of springs, each rotating around its own trunnion point, support the bogie axles through huge rubber Shock Insulators. The wheels conform freely to whatever irregularities the terrain presents without imposing the slightest twisting stress upon the frame.

The LRSW is equipped with hydraulic power steering which actually permits the driver to steer the big truck as easily as a new pleasure car. To provide still further driving ease the individual driver's seat and controls are offset to the left, assuring maximum vision both forward and to the rear.

For additional information write Mack Trucks, Inc., Empire State Building, New York City, *referring to* World Oil *item* 93.

ALTEN UNIT PUMPERS



UNIT SHOWN A-50-TC

Quality Features Include:

★ High-Capacity Double-Reduction Gear Reducer. Chrome-Nickel Steel Pinions. Hardened Steel Gears. Helical Shaved Gearing. Roller Bearing Equipped Throughout.

★ Double-Row, Spherical Self-Aligning Wrist Pin and Equalizer Roller Bearings.

★ Rigid, All-Welded, Structural Steel Samson Post and Frame.

★ Adjustable Stroke Lengths, Effective Balancing, For Use With Gas Engine or Electric Motor.

★ High Efficiency. Weatherproof Construction.

SEND FOR NEW CATALOG

Complete Pumping Unit Specifications Also illustrates Alten Casing Heads, Stuffing Boxes, Stop Cocks and hundreds of other production items

ALTENS
FOUNDRY AND MACHINE WORKS, INC.
LANCASTER, OHIO
Established 1889
Sold Through Dealers Everywhere

94—Pipe Joint Compound

This improved pipe joint compound known as Plastic Lead Seal 2 (Underwriters' Laboratories Approved) can be had in 1-, 2-, 4- and 8-ounce tubes.

Brushed-on threads gaskets, flanges, studs, bolts, nuts and plugs, it stops galling or rust of threads and never hardens or dries out. It assures tight, permanent joints that are easily taken apart later. The compound does not injure or stain polished finishes, is insoluble, will not wash out and seals air, water, steam, refrigerants, butane, propane, other petroleum derivatives, CO^2, etc., at temperatures to 500° F. On well-finished surfaces, it has been used as a seal in place of a gasket.

For additional information write Crane Packing Company, 1800 Cuyler Avenue, Chicago 13, Ill., *referring to* World Oil *item* 94.

You'll recover more oil . . .

with LARKIN PACKERS

No cement is needed to help this Larkin Type PRM Modified Upside Down Packer hold pressures on input or injection wells. It's easily removed for cleaning operations. Works with air, gas or water drives.

Larkin's Style JA Lodi Disc Flood Packer will form a gas-tight bridge at shallow depths until cement is run. This type packer is usually set in a shell above the shot hole, following which the disc is broken releasing the spring-held cone into the rubber.

This style OCC Larkin Disc Flood Packer is for use in flooding operations where cement is run on the packer and where a bridge for the cement is the essential purpose of the packer. This packer consists of a top cone for the packer rubber expansion and a disc type slip spring release assembly.

Your secondary recovery operations will result in greater oil production when you use Larkin packers, specially designed for secondary recovery work. You'll find Larkin packers seal completely, allowing pressure build-up when desired and preventing water seepage at all times.

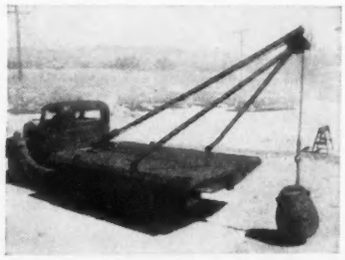
Larkin packers are designed for quick, and convenient installation. They are available in sizes and styles to meet every secondary recovery packing need. See your local supply dealer for complete information or write today for our catalog.

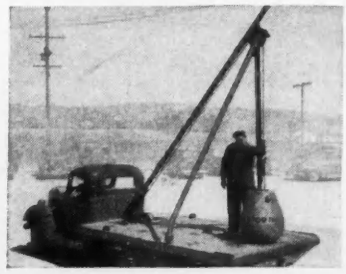
LARKIN *and Co. Inc.*
PACKERS & SAND PUMPS
OIL FIELD SPECIALTIES
BUTLER, PA.

95—Truck-Mounted "A" Frame

Designed to provide a safe, efficient means of hoisting loads on or off any flat bed truck, the Blackman E-Z "A" Frame can be operated by only one man throughout the full procedure of picking up, loading, transporting and unloading. In addition to its time and manpower saving features, it requires no more rig-up or tear-down time than regular chain-held masts.

The Blackman E-Z "A" Frame consists of two steel side legs supporting a slideable center leg assembly. The center leg assembly consists of a hinged mandrel, a sliding outside tube mounting a steel sheave and block, and a spring-loaded steel cylinder. As the head is winched vertically, the sliding tube remains extended until contacted by the winch line socket. Further pull causes the tube to slide down the hinged mandrel to compress a heavy coiled spring in a cylinder at the base of the mandrel. As the tube slides down the mandrel and compresses the coiled spring, the load being winched swings in over the truck bed. At this point, the mandrel and sliding tube are locked by inserting a pin through matching slots of the tube and mandrel. Once the assembly is locked in over-the-bed position, the load can be lowered onto the truck bed for transporting.





For additional information write Paul F. Blackman Manufacturing, P. O. Box 72, Los Nietos, Calif., *referring to* WORLD OIL *item* 95.

96—Water Cooler

A new ten-gallon water cooler is manufactured from heavy galvanized steel of all-welded and double lock seamed construction.

The completely insulated cooler is equipped at the factory with a spigot into which is screwed a standard three-eighths-inch pipe plug. The cooler is also available in three and five-gallon sizes. The same spigot used for the smaller coolers fits the ten-gallon size, and can be quickly installed or removed for instant conversion.

For additional information write The Igloo Manufacturing Company, 3807 McKinney Avenue, Houston, *referring to* WORLD OIL *item* 96.

YOU'RE OUT AHEAD *with* Foster CATHEADS *and* Aetna BEARINGS

On drilling rigs the world over more Foster Catheads are in operation than all other makes combined . . . including the majority of rigs which have set new drilling depth records from year to year. This preference logically stems from design and operational advantages which assure maximum safety, dependability and economy.

One potent reason for their reliability is the fact that they are equipped with Aetna bearings custom-engineered to "smile" at the most extreme load and speed conditions this application can impose.

In this, as in an increasing number of the oil country's toughest bearing assignments Aetna excellence unfailingly pays off . . . helps to avoid costly town-time . . . to pare down maintenance expense . . . to stretch equipment life. For money saving, problem solving counsel on oil country bearing applications, submit your prints to Aetna. No obligation, of course!

Aetna

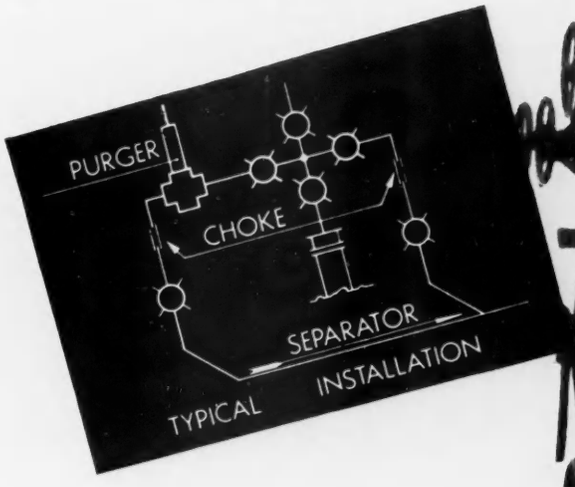
AETNA BALL AND ROLLER BEARING COMPANY
4600 Schubert Ave. • Chicago 39, Illinois

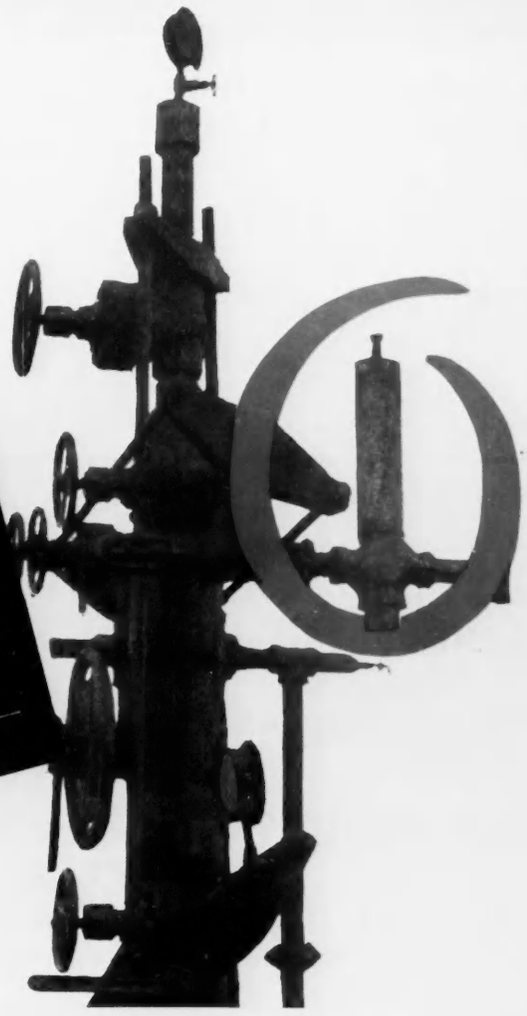
BALL AND ROLLER BEARINGS

STANDARD AND SPECIAL BALL THRUST BEARINGS • ANGULAR CONTACT BALL BEARINGS • SPECIAL ROLLER BEARINGS • BALL RETAINERS • HARDENED AND GROUND WASHERS • SLEEVES • BUSHINGS

Lengthen the flowing life of your Wells with the

"OMSCO" WELL PURGER





If your well is making water you NEED the "Omsco" Well Purger . . . for it will save you time . . . trouble . . . and money.

The "OMSCO" Well Purger is essentially a valve, installed in a by-pass line around the regular production choke, which operates by tubing head pressure. When the tubing pressure drops to a selected point, the Purger valve opens, starting the flow through a larger Purging Choke. This clears the tubing of water and when the tubing pressure increases to a desired point . . . the flow automatically is switched back through the regular production choke. By use of this purger many expensive swabbing jobs are eliminated . . . and the flowing life of a well lengthened.

Many oil wells flow to a point where a declining formation pressure necessitates the maintaining of a rapid flow rate to prevent liquid from falling back in the tubing and killing the well. At high rates of flow, such wells frequently produce excessive amounts of gas along with more oil than is desired. Producing such wells by stopcocking causes the production of excess gas.

By installing an "OMSCO" Well Purger on such a well, flow may be regulated so that normally the production rate is below the minimum required for steady flow. When tubing head pressure declines to where there is danger of flow stopping, the "OMSCO" Well Purger increases flow until an increase in tubing head pressure indicates the oil head has been produced and that the gas-oil ratio is increasing. The well is then automatically put back on the smaller choke.

Call at Your Nearest Wilson Supply Store or Write for Complete Information:

WILSON SUPPLY COMPANY

1412 MAURY ST., HOUSTON, TEXAS

SALES OFFICES: Tulsa, Oklahoma; Dallas, Texas.
SANTA FE SPRINGS, Calif.: Atlas Production, Inc.
1126 Lakeland Road

BRANCH STORES: TEXAS—Kilgore, Beaumont, Barbers Hill, Bay City, Monahans, Alice, Victoria, Corpus Christi, Columbus. LOUISIANA—Lake Charles, New Iberia, Harvey, Shreveport, Houma. ARKANSAS—Magnolia.

97—Petroleum Product Pumps

Information on use of pumps that combine the efficiencies of centrifugal action with positive self-priming and self-purging action is presented in a 12-page bulletin. It contains calculation tables, including a table of viscosities for different petroleum products, a table giving the head equivalents of various liquids and another of maximum practical suction lifts, and a compilation of friction loss in feet of liquid per 100 feet of clean steel pipe.

For a copy of Bulletin PM48, write Marlow Pumps, Ridgewood, N. J., *referring to* WORLD OIL *item* 97.

98—Steel Piling

A six-page brochure contains five cross-sectional views, with dimensions, of the light-weight interlocking corrugated sheet steel piling. A physical characteristics chart, discussion of the economics and advantages in using this type piling, and 23 suggested applications are included.

For a copy of this brochure, write L. B. Foster Company, Steel Warehousers, Box 1647, Pittsburgh 30, *referring to* WORLD OIL *item* 98.

Continuous circulation method cuts equipment cleaning time 50%!

IN AN attempt to increase the production capacity of his processing units, a Texas operator tried cleaning his equipment with live steam and hot water. This method proved ineffectual . . . costly. The Oakite Technical Service Representative was called in. He studied temperatures, pressures, deposits. He recommended a specially designed Oakite cleaner for quick, easy circulation through the entire system . . . absorber, heat exchanger, still pre-heater.

Result? Cleaning time cut in half! The penetrating power of the Oakite detergent broke through the carbonized deposits, grease films and basic sediment . . . product flow was smoother, output greater.

Oakite continuous circulation cleaning of processing equipment can save time and money for you! Ask the Oakite Representative near you for complete, free details of the method as it applies to your processing cycle. Or write for Oakite Petroleum Digest of 88 cleaning jobs. No obligations.

OAKITE PRODUCTS, INC., 37 Thames St., NEW YORK 6, N. Y.
Technical Service Representatives in Principal Cities of U. S. & Canada

OAKITE 1909 1949 40th ANNIVERSARY YEAR

OAKITE
REG. U. S. PAT. OFF.

PETROLEUM SERVICE DIVISION

99—Assembly Chains

Catalog RO-49 lists the various types of assembly chain designed for service on rotary rigs, oil well pumping units, general service pumps and other general applications. Construction features of the alloy steel chain are described in the 12-page illustrated booklet. Price lists for all chain series are given.

For a copy of this catalog, write Whitney Chain & Manufacturing Company, 237 Whitney Street, Hartford 2, Conn., *referring to* WORLD OIL *item* 99.

100—Diamond Drilling Bits

Experienced drillers and skilled engineers have not only developed new drilling equipment but have also improved drill bits and drilling techniques in recent years. A 16-page illustrated booklet describes the types of diamond drill bits now available for various drilling requirements, including core drilling, blast hole drilling, quarrying, ventilation holes and stoping operations.

For a copy of this booklet write Anton Smit & Company, Inc., 333 West 52nd Street, New York 19, *referring to* WORLD OIL *item* 100.

101—Direct Depth Reading

The Depthometer is a direct-reading device that gives accurate depth measurements in only the time it takes to make a run in with the tools to any desired depth in the well. The instrument can be used in bailing, clean-out, swabbing, single-shot surveys and similar sand line or drilling line operations.

A four-page folder itemizes 14 points, in using and taking care of the device, which is illustrated and described.

For a copy of this folder write The Cavins Company, 2853 Cherry Avenue, Long Beach 6, Calif., *referring to* WORLD OIL *item* 101.

102—Jet Perforating

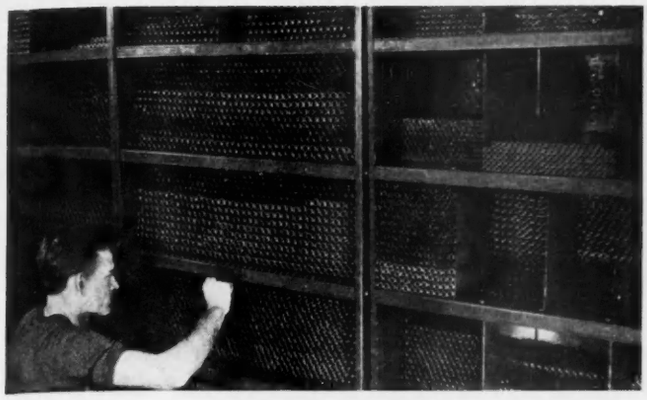
Bulletin JP-1-49 describes the uses of Welex Jet services on casing perforating jobs. The jet is a high velocity, directionally controlled penetrating force which derives its energy from the electronic detonation of a specially developed charge. Because of its high velocity of over 25,000 feet per second, about ten times bullet velocity, the perforating jet is not deflected from the casing wall.

For a copy of this bulletin, write Welex Jet Services, Inc., 3909 Hemphill Street, Fort Worth 9, *referring to* WORLD OIL *item* 102.

103—Triplex Slush Pumps

Bulletin SP-48 describes the Model T-880 and Model T-440 triplex slush pumps. The 16-page booklet presents applications of the pumps in the field, performance charts and construction details.

For a copy of this bulletin write to International Derrick & Equipment Company, 1317 Pacific Avenue, Dallas 1, *referring to* WORLD OIL *item* 103.



Single X and Double X Lathe Cut
SEAMLESS NIPPLES

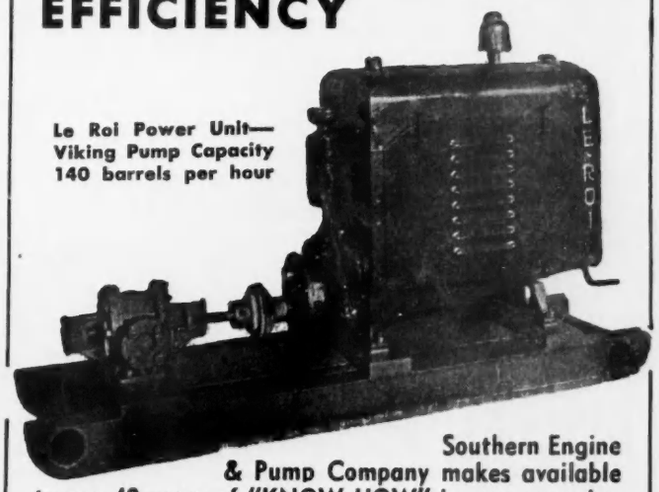
• Large stocks guarantee that your supply store can furnish you promptly these precision manufactured nipples.

Plastic coating protects threads from rust and handling damage. Sizes 1/4" to 6 5/8" in standard lengths. Special sizes, stainless and monel to requirements.

Sold Only Through Supply Stores
Write for literature and price lists.

Longhorn MACHINE WORKS
6823 Navigation
Houston, Texas
Dallas Branch: 3901 Southwestern

THE RIGHT TEAM FOR EFFICIENCY



Le Roi Power Unit—
Viking Pump Capacity
140 barrels per hour

Southern Engine & Pump Company makes available to you 40 years of "KNOW HOW" in your pumping requirements.
• Complete units and replacement parts at all branches.

SOUTHERN ENGINE & PUMP COMPANY

MANUFACTURERS • MACHINERY FACTORS • CONTRACTORS
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The Story of AVONDALE and the OIL BUSINESS

Giant STEEL platforms built for offshore drilling. Write for details.

From WAR to OIL... Conversions of all types and sizes of craft.

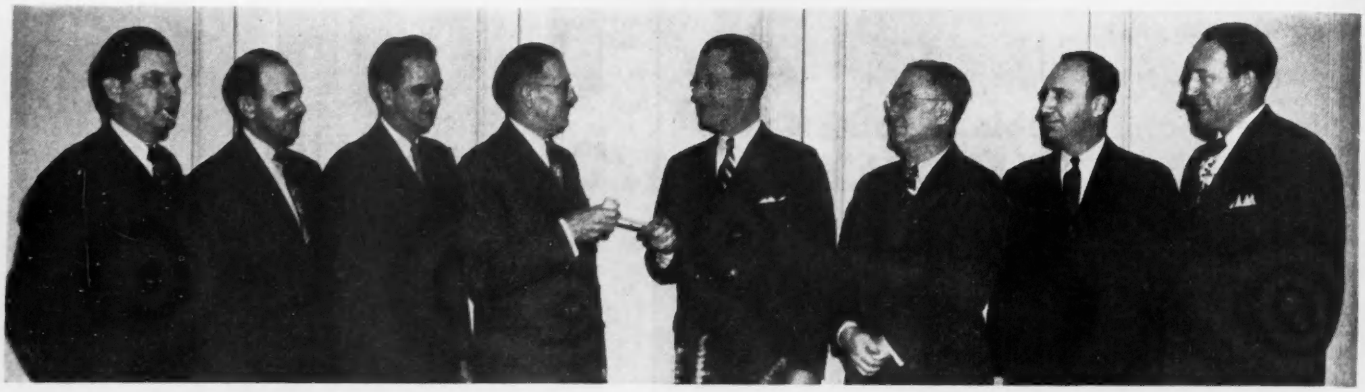
Personnel and service launches built of STEEL! Speedy, efficient, rugged.

Towboats built and repaired. Marine work is our specialty.

AVONDALE MARINE WAYS, Inc.

Main Plant: Avondale, La. *Quick Repair Plant: Harvey, La.*
MAIL: WESTWEGO, LA.

Associations

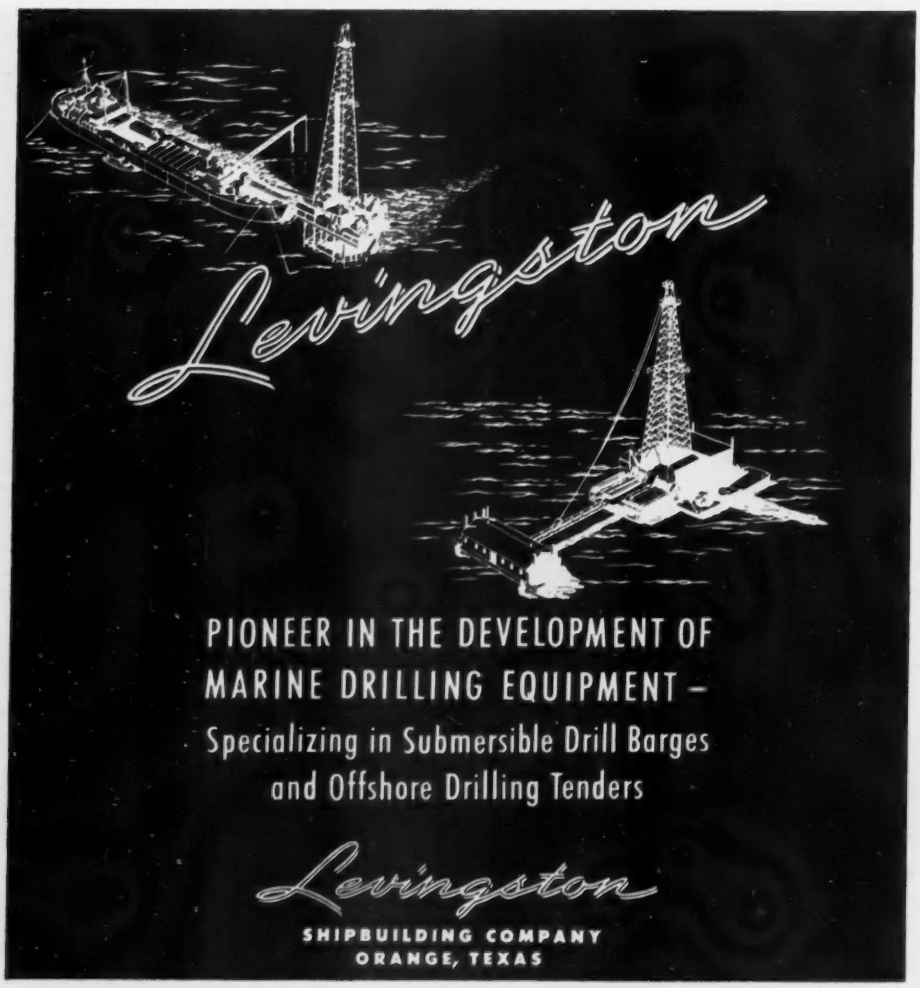


NEW YORK NOMADS OFFICERS—New officers of the New York Chapter of Nomads are, left to rigth, R. V. McIntire, secretary; M. F. Delano, assistant treasurer; C. P. MacDonald, Jr., treasurer; Val R. Wittich, Jr., regent and out-going president; James W. Reed, president; W. D. Robinson, vice president; K. D. Demarest, assistant sergeant-at-arms; E. T. Landgraff, assistant secretary. Officers who are not pictured are Marvin D. Rasher, sergeant-at-arms, and A. V. Simonson, regent.

AAODC Ninth Annual Meeting Set for Sept. 19-21 at Dallas

The Ninth Annual Meeting of American Association of Oilwell Drilling Contractors will be held in Dallas September 19-21, Joseph S. Morris, president, has announced.

Major Dallas hotels have assured the association of their full cooperation. Meeting headquarters will be in the Baker Hotel.



Wire Rope Institute Names David Larkin President

At the annual meeting of the Wire Rope Institute, David Larkin was elected president, succeeding E. C. Low of John A. Roebling's Sons Company, who became chairman of the board.

David Larkin

Larkin, executive vice president of the Broderick and Bascom Rope Company, has been associated with the wire rope industry for 21 years. A graduate of the University of Edinburgh, Scotland, he is chairman of the advisory board, Washington University School of Engineering, St. Louis, and a fellow of the American Society of Mechanical Engineers.

Other new officers of the institute are H. C. Parker, Bergen Wire Rope Company, vice president; W. A. Huber, American Chain and Cable Company, secretary; and D. W. Vernon, A. Leschen and Sons Rope Company, treasurer.

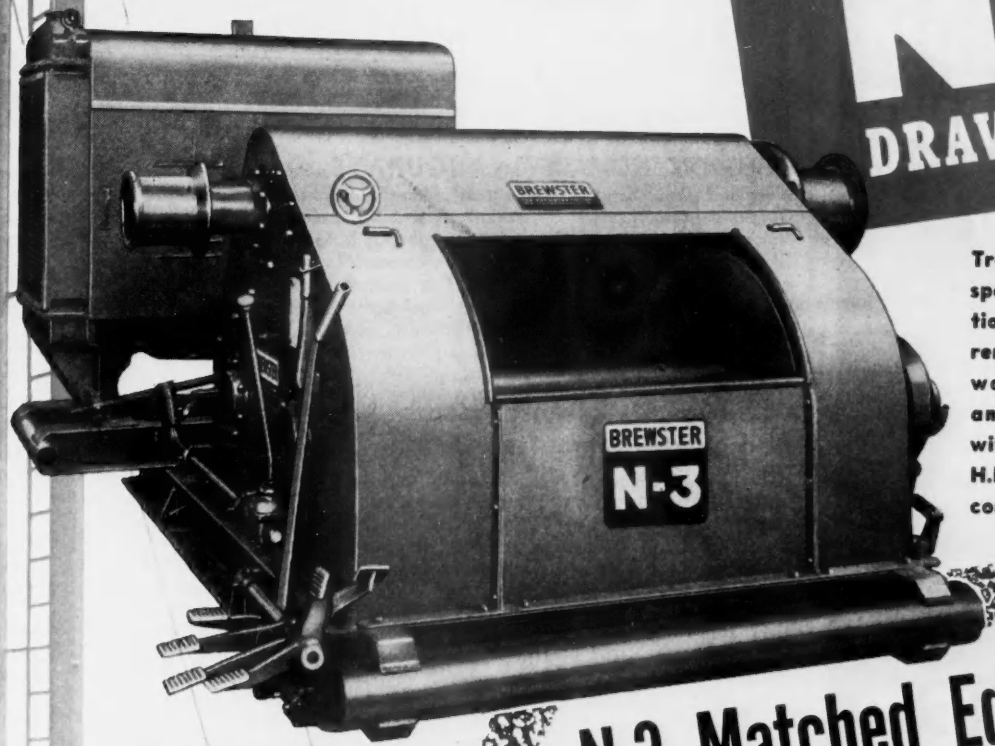
Texas Mid-Continent Oil & Gas Association Plans Meetings

Texas Mid-Continent Oil and Gas Association will hold its 1949 annual meeting October 13 and 14 at the Rice Hotel in Houston.

The 1950 meeting of the association will take place in Dallas October 4 and 5. Beaumont will be host city for the meeting in 1951, which is the decennial anniversary of the discovery well in Spindletop.

Driller's FAVORITE FOR DRILLING TO 3500' · SERVICING TO 7000'

BREWSTER N-3 DRAWWORKS



Transmission has 4 forward speeds; 1 reverse. Front section of drum guard easily removed for well servicing work. Available in single and double drum models with any popular make 145 H.P. engine. Write today for complete information.

Compact—portable—extremely efficient—the Brewster N-3 Drawworks meets every requirement for fast, economical shallow drilling.

The N-3 was formerly known as the 70-B. Only the name has been changed. Same fine engineering and workmanship. Same favorite features of the famous 70-B.

N-3 Matched Equipment

3-S SWIVEL

H-50 BLOCK

OB-12-L ROTARY

The Brewster N-3 Drawworks is available with 55' or 65' telescoping mast. Shown here, mast is in first position—ready to be raised by drawworks motor to 55' or 65'. Three sheave crown block is integral part of mast.

Write for Catalogs

The BREWSTER CO., Inc.

Manufacturers of Drilling Equipment Since 1910

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BREWSTER *Drilling Equipment*

Sold by:
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Grime does not pay
It's Waterless
Oil Base
HAND CLEANER
Easy on greasy hands
All you do is rub a dab of Oil Base Hand Cleaner on your hands, like ordinary soap, until grime dissolves—then wipe off on rag or paper towel. Needs no water. Cuts grease, oil, tar, creosote, paint, printers' ink, Black Magic oil base drilling fluid. Soothes cuts, scratches and chapped skin. On sale at supply stores. Write for free sample.
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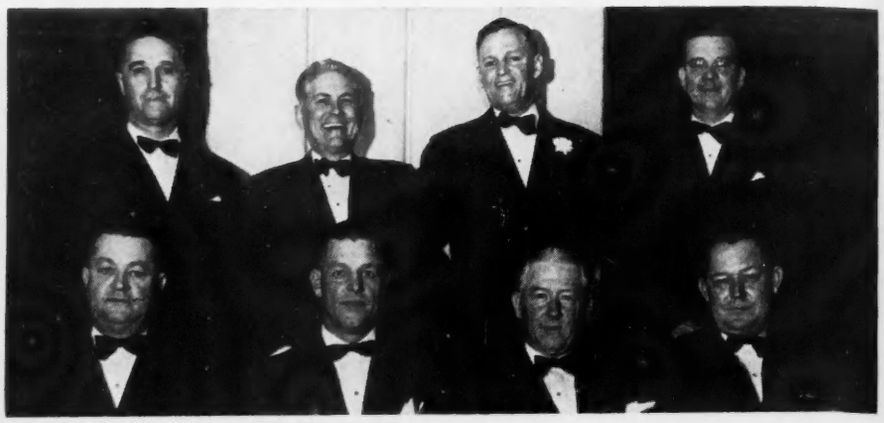
ASSOCIATIONS



HOUSTON NOMADS INAUGURATE—Four hundred and fifty Houston Nomads, wives and guests attended the annual dinner dance and inauguration of officers at the Rice Hotel. Outgoing president H. E. Thornhill, Thornhill-Craver Company, was presented two gifts by the Nomads. Officers for 1949 are, left to right, C. B. McDonald, A-1 Bit & Tool Company, president; Ed Fontaine, National Tank Company, vice president; E. L. Lorehn, Cameron Iron Works, secretary and treasurer; Wayne Rives, *Oil and Gas Journal*, assistant secretary and treasurer. Standing, left to right, E. F. (Salty) Baldwin, Hughes Tool Company, sergeant-at-arms; Carroll W. Wood, Howard Smith Company, assistant sergeant-at-arms; Thornhill, regent; and H. E. Estes, A-1 Bit & Tool Company, executive secretary.

API Appoints Research Head And Makes Committee Changes

H. J. Struth, veteran oil economist and analyst, has joined the staff of the American Petroleum Institute in New York as head of the Research Section in the Department of Information.

Struth resigned the editorship of the *Petroleum Data Book* to accept the position.

Struth has been in the petroleum industry for 31 years. He spent ten years with Mid-Continent Oil and Gas Association as an economist and administrative assistant. During the NRA days he served in Washington as technical adviser to the Petroleum Administration.

M. J. Morash, of the Transit & Storage Company, Port Huron, Mich.; A. E. Wolf, of the Standard Oil Company (Ohio), Cleveland, and D. J. Schreiber, of the Petco Corporation, Milwaukee, have been appointed to the API's financial and accounting committee.

In the Mid-Continent committee Division of Production, James A. Bermingham, Jr., division engineer, The Texas Company, Tulsa, chairman of the registration committee, succeeds H. R. Bolton. Whitney M. Elias, chief engineer, Producing department, Standard Oil and Gas Company, Tulsa, is chairman of the entertainment committee, succeeding C. F. Bedford. Both Bolton and Bedford resigned due to transfers from the district.

Texas Producers and Royalty Owners Group States Views

Imports should supplement, not displace, domestic production to supply U. S. markets, it was declared by the executive committee of the Texas Independent Producers and Royalty Owners Association at Austin.

With reference to bills introduced in the Texas Legislature, the association declared itself unequivocally opposed to Senate Bill 24, Section 5, which it declared would permit abrogation of present anti-trust laws. Senate Bill 73, designed to establish a standard for the measurement of a cubic foot of gas, received the full endorsement and support of the association.

The group endorsed House Resolution 79, which was introduced in the 81st Congress, designed to amend the Natural Gas Act.

With a prospect of about 8 percent more tonnage of steel tubular goods for the oil industry in 1949 over 1948, some operators were of the opinion that the pending voluntary allocations program might be unnecessary.

The annual meeting of the association will be April 1 at Houston.

AIME Charles F. Rand Medal Awarded to Late H. C. Wiess

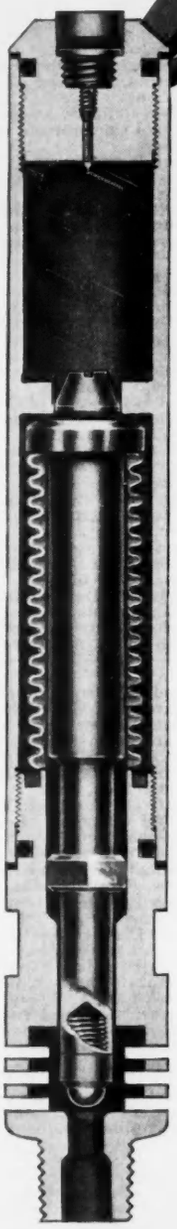
The late Harry C. Wiess, president of Humble Oil & Refining Company, is the recipient of the Charles F. Rand Medal for 1949, it was announced by the AIME. The award is made from time to time to recognize distinguished achievement in mining administration.

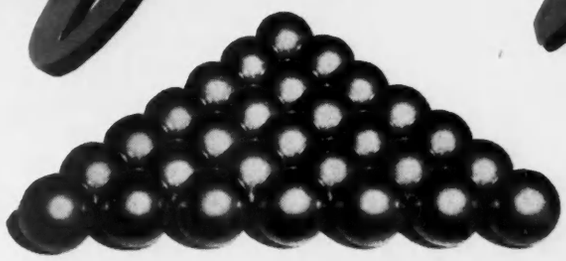
Wiess was cited "For energy, wisdom, and administrative ability which found expression in major contributions to the economy of the nation and the world; for high courage and vision in services to the petroleum industry; for ceaseless efforts in fostering during World War II the production of strategic supplies; for a greatness of character which showed itself in his many philanthropies and in the respect of all who knew him."

Safety Group Elects Ball

Baxter F. Ball, northern California division manager of General Petroleum Corporation, has been elected president of the San Francisco chapter of the National Safety Council. Ball has been a member of the Council's board of directors for the past two years.

Uniformity





Important in Gas Lift, too . . .

Uniform action of each individual valve in the string is absolutely vital if *full efficiency* is to be obtained in gas lift operations. Erratic performance of *just one valve* can be extremely costly.

Being fully protected against varying factors that affect ordinary valves, GOT-OLSCO Type "O" Gas Lift Valves provide absolutely uniform action and *unequalled efficiency*. The seamless Monel bellows retain their original size and shape and can not be damaged by any differential pressure . . . there are no springs to cause erratic action . . . dome pressures are securely sealed and remain constant, *unvarying* factors throughout the life of the valves.

For *efficient* gas lift, use GOT-OLSCO Type "O" Valves . . . the valves that provide complete uniformity, complete dependability, utmost economy. They're suitable for *constant* flow, *intermittent* flow and *dual completions.*

Our new home in Houston is fully stocked and equipped to provide quick delivery, repair and service.

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OLSCO MFG. COMPANY
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Anniversary Will Be Observed By Colorado School of Mines

The school year 1948-1949 is the 75th in the history of the Colorado School of Mines, which was established by the Colorado territorial assembly in 1874. The final and main phase of the anniversary celebration will be held September 29 and 30 and October 1.

September 30 and October 1 conferences will be conducted on the general theme of the anniversary, "Mineral Resources in World Affairs." A general conference is scheduled on the subject of the economics of the mineral industry. Friday afternoon and Saturday morning will be devoted to separate conferences in geology, geophysics, mining, metallurgy, petroleum production and petroleum refining.

Wildcatters Elect

R. M. Chan, vice president, Magnolia Petroleum Company, Dallas, Texas, has been named chairman of the Dallas Wildcat Society. Other officers include Ray Hubbard, vice-chairman and Cresslyn Alexander, secretary-treasurer.

Star's "Rubber-Mount" design places 30 rubber mountings under the crown sheave (illustration below) and in the spudder. The spudder floats completely on rubber at all bearing points and sheaves.
The NEW No. 72
"Rubber-Mount"
SPEED STAR . .
✔ NEW, PROVEN DESIGN
✔ NEW DRILLING ACTION
✔ NEW EARNING TOPS
. . . ONE OF A SERIES OF MODERN, • PROFIT-MAKING • DRILL RIGS BUILT BY A COMPANY 60 YEARS IN BUSINESS
ANOTHER "FIRST"—
Star's patented "Rubber-Mount" design, which gives full protection to the machine and develops a powerful drilling motion with terrific penetrating ability. The No. 72 Speed Star easily swings tools averaging 2500 lbs. on wells 6" to 16" diameter. It is ideal for the drilling and cleaning out of shallow wells.
Ask for Bulletin No. 72-B.
OTHER No. 72 FEATURES:
1. Star's famous balanced construction distributes load, eliminates side strain and prolongs life.
2. Double catheads are regular equipment, with friction clutch control for safety.
3. Extra large capacity masts with power hoists.
4. Three full-width reels, chain-driven, with friction clutch controls, provide flexibility for all operations.
5. 23 anti-friction bearings conserve power and lengthen service.
Mountings: truck, full trailer, semi-trailer.
"If It's a Speed Star, It's a Fast, Proven Money-Maker"
THE STAR DRILLING MACHINE COMPANY
475 WASHINGTON STREET • AKRON 11, OHIO
Drilling Machines and Tools Since 1889

THE OIL MAN'S CALENDAR

MAR. 7–10	Manufacturers Standardization Society of the Valve and Fittings Industry, Annual Meeting, Commodore Hotel, New York, N. Y.
9–11	American Petroleum Institute, Southwestern District Meeting, Galvez Hotel, Galveston, Texas.
11	American Gas Association, Great Lakes Personnel Conference, Spring Meeting, Palmer House, Chicago.
14–17	U. S. Geologists, 34th Annual Meeting, Jefferson Hotel, St. Louis.
17–18	Oklahoma Utilities Association, Annual Convention, Hotel Tulsa, Tulsa.
23–25	American Petroleum Institute, Mid-Continent District Meeting, Mayo Hotel, Tulsa.
25	Illinois Oil and Gas Association, Annual Meeting, Hotel Emmerson, Mount Vernon, Illinois.
APRIL 4– 5	Industrial Accident Prevention Association Convention, Royal York Hotel, Toronto, Canada.
4– 6	American Gas Association, Distribution Motor Vehicle and Corrosion Conference, Netherlands-Plaza Hotel, Cincinnati.
11–14	National Association of Corrosion Engineers, Netherlands-Plaza Hotel, Cincinnati.
12–14	Southwestern Gas Measurement Short Course, College of Engineering, University of Oklahoma, Norman.
18–20	Midwest Power Conference (11th Annual Meeting), Hotel Sherman, Chicago.
20–22	Southern Gas Association Convention, Buena Vista Hotel, Biloxi.
22–23	Colorado School of Mines, 15th Annual Engineers' Day, Golden, Colorado.
27–29	American Petroleum Institute, Eastern District Meeting, William Penn Hotel, Pittsburgh.
MAY 3– 4	Independent Petroleum Association of America, Mid-Year Directors Meeting, New Orleans.
9–10	American Gas Association, Natural-Gas Department, Spring Meeting French Lick Springs Hotel, French Lick, Ind.
9–11	Interstate Oil Compact Commission, Spring Quarterly Meeting, Roosevelt Hotel, Jacksonville, Fla.
9–11	Liquefied Petroleum Gas Association, Annual Convention and Trade Show, Palmer House, Chicago.
12–13	American Petroleum Institute, Division of Production, Pacific Coast District Meeting, Biltmore Hotel, Los Angeles.
26–27	American Petroleum Institute, Rocky Mountain District, Gladstone Hotel, Casper, Wyoming.
26–27	The Natural Gas and Petroleum Association of Canada, Annual Meeting, Hotel London, London, Ontario.
30–31–June 1	Southern Gas Association, Fourth Annual Short Course in Gas Technology, Texas College of Arts and Industries, Kingsville, Texas.
JUNE 5– 7	Petroleum Equipment Suppliers Association, 14th Annual Meeting, Broadmoor Hotel, Colorado Springs, Colo.
16–17	Pennsylvania Grade Crude Oil Association, Annual Meeting, Hotel William Penn, Pittsburgh.
SEPT. 19–21	American Association of Oilwell Drilling Contractors, Ninth Annual Meeting, Baker Hotel, Dallas.

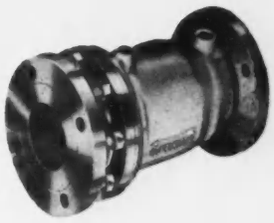
Nomads Chapter monthly meetings: **Los Angeles**, second Wednesday, Jonathan Club, B. M. Landis, Secretary. **Houston**, second Monday, Houston Club, Harry E. Estes, Secretary. Telephone Charter 4-7611. **Dallas**, L. A. Little, Secretary. Telephone Justin 8-1726. **Tulsa**, third Wednesday, Hotel Tulsa, Anthony Gibbon, Secretary, Telephone 3-1844. **New York**, first Monday, Louis Sherry's, Norris Boulden, Secretary, Telephone WIckersham 2-1311, extension 260.

IN THE CONTROL OF . . .

AIR . . . . . GAS . . . . . LIQUIDS

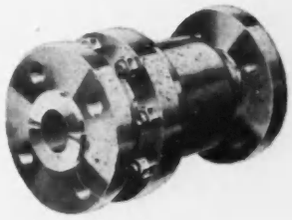
GROVE takes the new approach to old problems

Since its inception, Grove Regulator Company has pursued the course of developing new and better means of solving old problems. Research, a basic and essential part of this long range program, has been directed by practical field experience. The rapid strides of Grove in the sphere of fluid control reflect the tested and proved principles embodied in Grove products. Typical of such outstanding Grove developments are those shown.



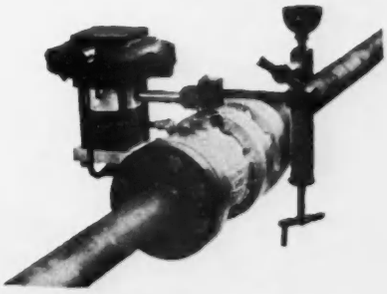
FLEXFLO

Expansible tube type valve for cold fluid services, handles oil, water, solutions, gases and air. Corrosion and erosion resistant. Self-operating by various remote control combinations.



CHEXFLO

Fully self-contained, self-operating check valve, closes on balanced flow prior to the start of return flow. Ideal for handling corrosive fluids or gases. Bubble-tight shut-off, no metallic moving parts.

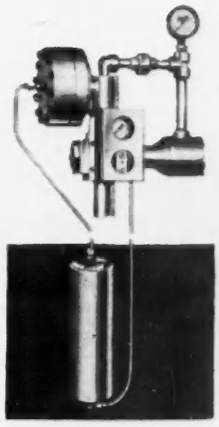


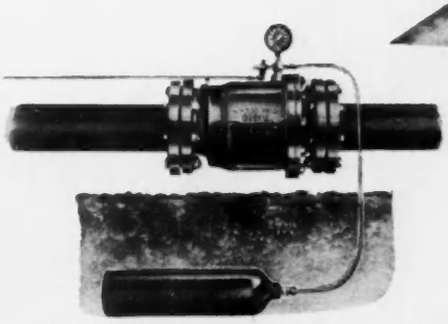
MODEL 898
SEPARATOR OIL VALVE

Pressure-balanced operation with closed actuating system sealed off from line fluid. Self-compensating for wear, handling the most abrasive fluids. No seep or leak—just set it and forget it.

MODEL PB-300
REGULATOR

For severe services, as a back pressure or pressure reducing regulator, stands up to toughest conditions. Working parts protected from gas blast, resists freezing or sand cutting. Handles pressures up to 6000 lbs. reducing, 3000 lbs. back pressure service.





MODEL 888 PRESSURE LOADED RELIEVER

Instant response to slightest variation in line pressure, opens and closes smoothly with no sticking, chattering, leakage or failure. Equally suitable as Back Pressure Regulator opening on constant or intermittent flow.

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GROVE SIMPLICITY ACCURACY SAFETY

Pressure and Flow Control

SYSTEMS & EQUIPMENT

Men in the Industry NEWS

H. F. Sinclair, founder and chief executive of the oil companies bearing his name for the past 33 years, has resigned the presidency of the parent company, Sinclair Oil Corporation, and has been elected chairman of the board of directors. **P. C. Spencer,** now president of the principal operating subsidiary, Sinclair Refining Company, and executive vice president of the corporation, succeeds Sinclair as president of the corporation.

P. C. Spencer

Sinclair stated that with the completion of the modernization and expansion program initiated in 1945 and involving expenditures of more than $150 million, he desired to be relieved of the active direction of operations.

Spencer's active connection with the oil business began in 1922 when he joined the Producers and Refiners Corporation. In addition to his activities in the oil business, Spencer has held executive positions in natural gas companies for a number of years, including president of Southwestern Development Company, president of Canadian River Gas Company, and vice president and director of Colorado Interstate Gas Company. With the acquisition of the Prairie companies, of which Producers and Refiners Corporation was a subsidiary, Spencer became active in the Sinclair organization, moving to New York in 1934, and was elected general counsel of the corporation in 1946.

»

Frank Williamson has been appointed manager of the Permian Basin office opened at Midland, Texas, by Stephens Petroleum Company and associated interests of Oklahoma City.

»

F. P. Herbst has resigned from the Land department of the Bridgeport Oil Company, Wichita, Kansas, to become manager of the Land department of the Cooperative Refinery Association at Kansas City, Mo.

»

L. W. Elderkin, formerly assistant district superintendent for Shell Oil Company at Great Bend, Kansas, has been made district superintendent at McPherson, Kansas, succeeding the late **R. T. McNally.**

John Post, formerly manager of the employe relations department of Standard Brands, Inc., New York, has been named manager of Continental Oil Company's new Industrial Relations department and will direct the company's personnel, labor relations, safety, pension, insurance, health, credit union, recreation and other employe benefit programs. He received his B. S. degree at Columbia University in 1933 and his law degree from the same school in 1936. He is one of the youngest industrial relations managers of a major industry in the U. S.

John Post

In Continental's Exploration department, **H. R. Prescott,** formerly chief geophysicist, has been promoted to assistant manager. **B. G. Swan,** formerly superintendent, seismic division, has been named chief geophysicist, and **L. E. Whitehead,** formerly area supervisor for seismic work in Oklahoma and Kansas, has been appointed superintendent, seismic division.

»

William E. (Cap) Murrah resigned as secretary-treasurer of Creslenn Oil Company, Dallas, to become secretary of Transcontinental Gas Pipe Line Corporation. Murrah has been connected with Transcontinental since its organization in 1946. He has been with Creslenn as secretary-treasurer and office manager of its various interests since 1945. Prior to that, he was with Phillips Petroleum Company doing field work for the Production and Gasoline Plant Construction departments and later was connected with Cities Service Oil Company in the Treasury and the Federal Tax departments.

»

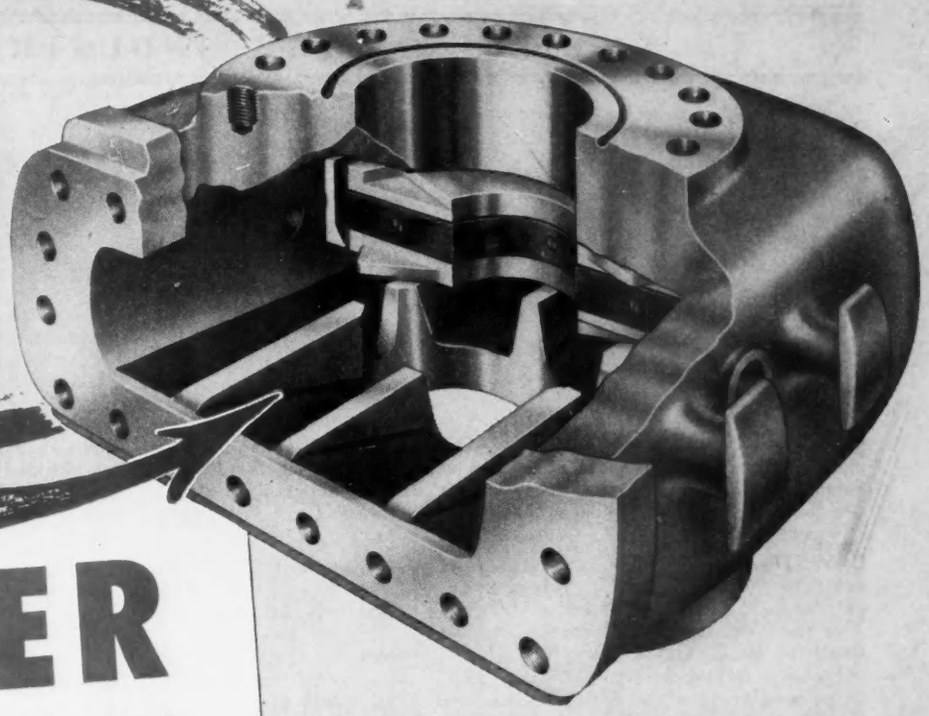
R. N. Hastings has been named district superintendent for Stanolind at Alvin, Texas. Hastings transfers to Alvin from Ulysses, Kans. He succeeds **F. C. Beleau,** who was made division drilling superintendent for Stanolind at Casper, Wyo.

»

John F. Cullen, veteran Rocky Mountain division manager for Stanolind at Casper, has been named division consultant and will be succeeded as division manager by **Carl L. Larsen, Jr.,** formerly division exploration superintendent at Casper. **William B. McCabe,** division geologist, has been promoted to the exploration superintendent's post. Cullen asked to be relieved of part of his responsibilities for Rocky Mountain operations but will continue to take an active part as a policy adviser and as a special representative handling important assignments.

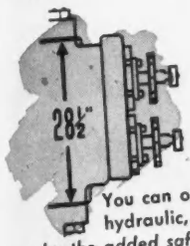
CATAWISSA
BALL-TO-ANGLE SEAT
gives you a
PERFECT SEAL...
...even when the pipe is not perfectly aligned!
HOT FORGED STEEL
STAINLESS STEEL
Full ACME Threads or U. S. V-Threads in Union nuts and on female end.
STANDARD AND DOUBLE EXTRA HEAVY
HOT FORGED from solid, rectangular steel bars, Catawissa Pipe Unions are free from sand and blow holes. The ball-to-angle seat design plus their ability to expand and contract with the pipe give you sure fire dependability . . . a perfect seal for every application!
DISTRIBUTED BY
OIL WELL SUPPLY COMPANY
BRANCHES SERVING ALL OIL FIELDS
WRITE FOR BULLETIN 10-A
CATAWISSA VALVE & FITTINGS COMPANY
CATAWISSA, PENNA.

This is why Sand and Mud cannot clog a

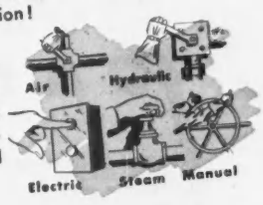


SHAFFER CELLAR CONTROL GATE

SHAFFER ALONE COMBINES SUCH IMPORTANT ADVANTAGES AS THESE...

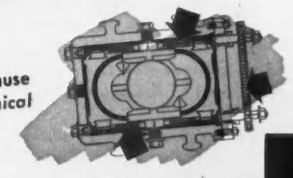


MAXIMUM COMPACTNESS: Even in the largest sizes, Shaffer Double Cellar Control Gates require less than 29" of cellar height—smaller sizes even less. This feature saves cellar space, simplifies installation!



ANY TYPE OF POWER: You can operate Shaffer Gates with air, hydraulic, steam or electric power drives—*plus the added safety of complete manual stand-by.* There's a choice of power to meet every well requirement!

EASY RAM CHANGES: Shaffer Rams can be completely changed by removing just ONE end cover. Saves time and work!



POSITIVE MECHANICAL DRIVE: Shaffer Gates are foolproof in operation because the rams are opened and closed by *direct mechanical drive* that is quick, simple, positive!

NON-CREEPING RAMS: Only one quick operation is required to both close the Shaffer Gate—and keep it closed. No auxiliary locking devices or extra operations are necessary because Shaffer rams *automatically* stay in the position they are set. An *extra* safety advantage!

THESE AND MANY OTHER ADVANTAGES make Shaffer Cellar Control Gates the outstanding equipment for modern pressure control operations. Send for full information on the many ways Shaffer Gates assure greater safety, maximum operating efficiency, simpler, more compact installations!

Send for your free copy of the new Shaffer Catalog!

See pages 3843 to 3894 of your 1948 Composite Catalog for information on the complete line of Shaffer products.

TAKE A GOOD LOOK AT THE ILLUSTRATION ABOVE

It is a portion of the Shaffer Cellar Control Gate you seldom see in the field because it is hidden inside the body—

BUT IT'S A VERY IMPORTANT PART

It is the *bottom* of the ram compartment in a Shaffer Cellar Control Gate—and it explains why Shaffer Gates remain clean and mud-free with minimum maintenance . . . always ready for quick, foolproof operation when pressure emergencies arise. See the high narrow ribs? These are the supports on which the rams travel, and the ribs are *narrow* to prevent sand and mud from gathering on the sliding surfaces—and *high* to hold the rams far above any mud or sand accumulations in the bottom of the Gate.

And note the steep inward pitch on the bottom of a Shaffer Gate. Any mud or sand that *does* get into the Gate drains back into the well, keeping the bottom of the Gate mud-free and clean. This mud-free construction is just one more of the many Shaffer features that insure maximum safety and dependability in modern cellar control gate protection . . . one more reason why you're far ahead when you equip *all* your wells with Shaffer Cellar Control Gates—the standard of the industry.

Important Older models of Shaffer Cellar Control Gates that do not have the self-draining feature described above can easily be modernized to incorporate this vital advantage. Write for full details!

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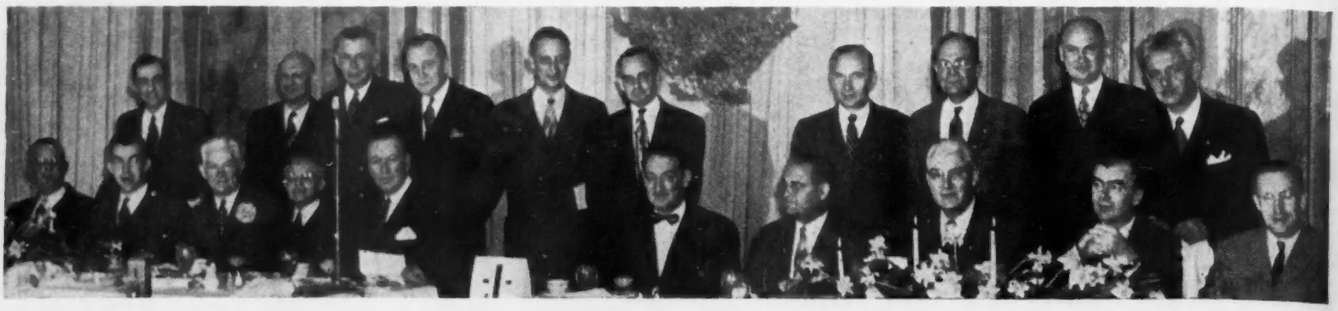
HIGH PRESSURE DRILLING AND CONTROL EQUIPMENT • FISHING TOOLS THAT EXCEL

SHAFFER TOOL WORKS, Brea, California • California Service Shops: Santa Fe Springs and Tart
HOUSTON, TEXAS, 6006 Navigation Blvd. • ODESSA TEXAS, 1925 West Second Street
OKLAHOMA CITY, OKLAHOMA, Acme Oil Tool Company, 1001 S. E. 29th Street
EXPORT SALES OFFICE: Shaffer Tool Works, 500 Fifth Avenue, New York, N. Y., U.S.A.



OVER 500 YEARS OF SERVICE—These 20 employes of the Shell Oil Company and Shell Pipe Line Corporation, all of whom have 25 or more years of service, are shown at the company's annual service award dinner last month at Houston. They are W. H. Cline, F. V. Maloney, A. M. Eaton, E. D. Cumming, F. W. J. Haas, G. Byers, D. B. Matthews, O. D. Story, F. W. Littell, L. C. Geiler, F. Goldstone, H. Fenton, F. J. Zander, O. G. Wilhelm, B. L. Ryan, H. H. Anderson, E. R. Mueller, A. E. Jago, L. M. Vreugde, and W. A. Baker.

C. W. Dawson has been appointed chief engineer of the Producing department of Standard Oil Company of California. The position was made vacant by the death of **H. B. Davis** recently.

Dawson joined Standard in June, 1929, as an engineer in the Maintenance and Constructon division at Kettleman Hills. He has held various engineering positions in the field since that time, transferring to his newest assignment from a position as district organizer and cost control supervisor at Taft.

Other recent appointments include **V. L. Taylor** as field superintendent, Coalinga area, Producing department, with **R. W. Norton** succeeding Taylor as assistant to the general manager (Operations), Producing department, San Francisco office.

Taylor has been with the company since May, 1935, starting as a petroleum engineer (Development) in the Southern California oil fields. He was graduated from University of California in 1935, with a degree in petroleum engineering.

Norton is also a graduate of University of California in 1935, with a degree in petroleum engineering. He joined Standard in May that year in the southern part of the state. He has held positions as district petroleum engineer and acting superintendent for the parent company and subsidiaries in Canada, petroleum engineer (Development), northern district, and senior petroleum engineer (Development), in the San Francisco office.

»

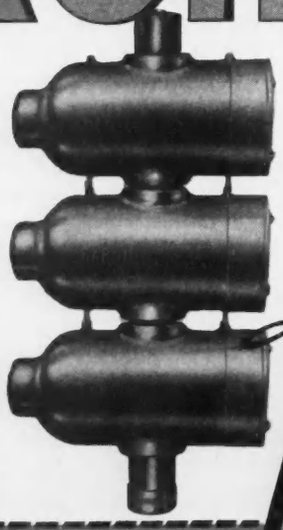
C. O. Puckett, landman for C. H. Murphy and Company at El Dorado, Ark., has been transferred to Midland, Texas, to head a new district there. **Ray M. Devero,** formerly with Skelly Oil Company, has joined the Murphy interests at El Dorado.

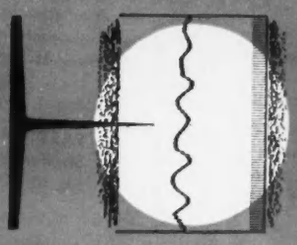
Thad Hoke, head of the Land and Geological department of British-American Oil Producing Company at Tulsa, has been appointed vice president in charge of the Exploration department.

CUT SURGE, SHOCK AND VIBRATION
ON MUD PUMPS WITH
BAROID
PULSATION DAMPENERS

Baroid Pulsation Dampeners absorb the shock and surge of all types of reciprocating pump installations, and more than save their cost by reducing damage to equipment and providing smoother, quieter operation. Some evidence even points strongly to the possibility that pulsation transmitted to the formation increases the chances of caving and lost circulation.

Simple to install—Simple in operation, Baroid Pulsation Dampeners have already proved their worth on many oil field installations. Write today for special bulletin giving complete details.





The cardiograph illustration at the right records the severe pressure shock of a 7¼"x14" duplex, double acting mud pump operating at 60 r.p.m. At this speed, pulsation varied from 793 p.s.i. to 302 p.s.i., producing a vibration impact of 491 pounds per sq. in. to every part of the system.

This recording was taken following the installation of a Baroid Pulsation Dampener. Note how the pressure line has straightened out. Reading remained at a constant 650 p.s.i.

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National Lead Company
City National Bank Bldg., Houston 2, Texas
Gentlemen: Please send me a copy of your new illustrated bulletin on "BAROID PULSATION DAMPENERS"
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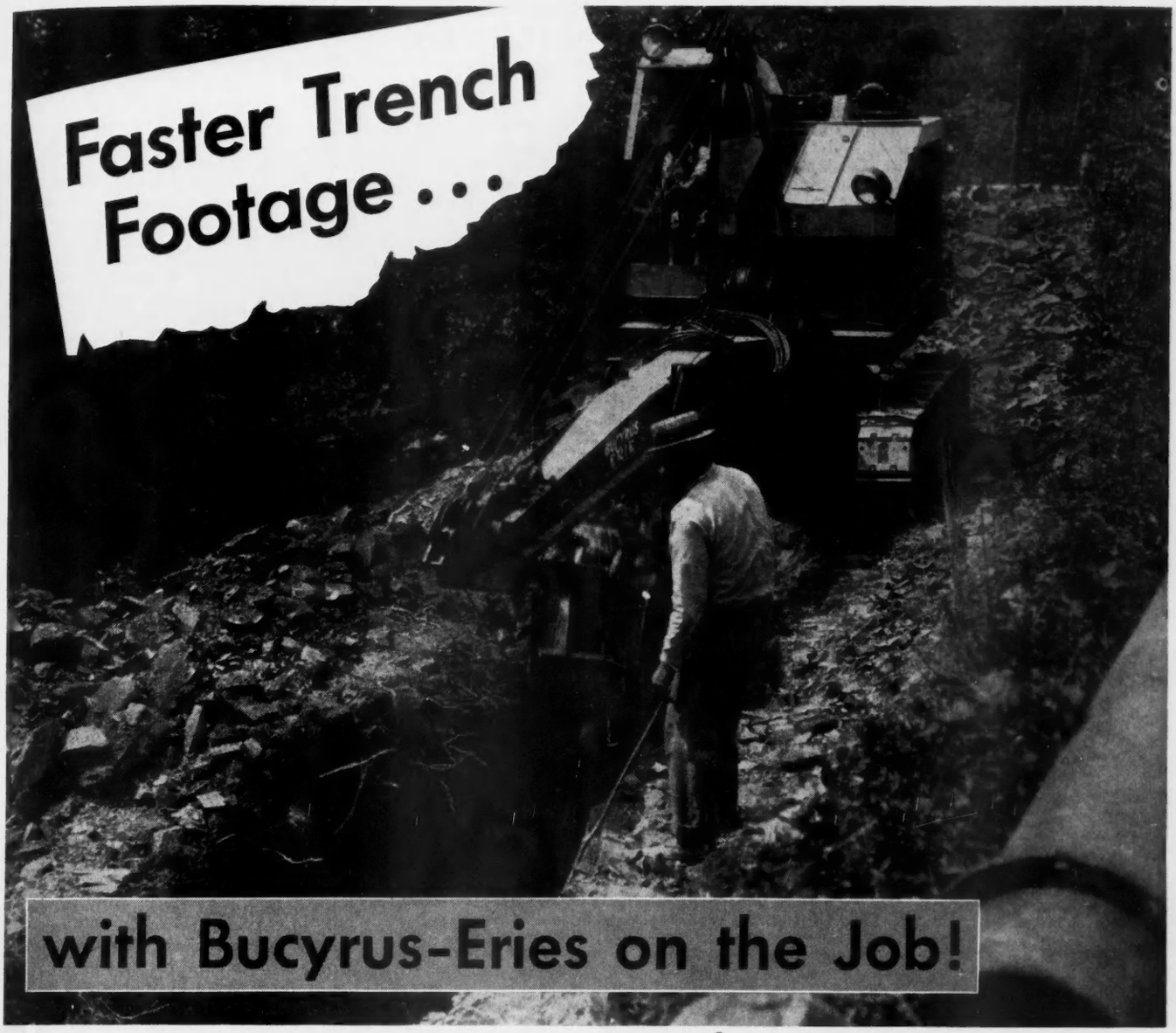
Title_____
Company_____
Street_____
City_____ Zone_____ State_____

SPECIALTIES DEPT.
BAROID SALES DIVISION
NATIONAL LEAD COMPANY
CITY NATIONAL BANK BUILDING, HOUSTON 2, TEXAS



THAT'S one thing you can be sure of when you put a Bucyrus-Erie dragshovel on your pipeline jobs . . . trenches grow fast, cut clean and true. Owners know that Bucyrus-Erie design means the balance of speed and power that steps up output . . . the quick hoist and swing that combines with a powerful digging stroke to produce big yardages in a hurry.

All-welded dragshovel dippers add to efficiency with an extended dipper lip that penetrates easily and helps the long sidecutters in holding extra material. They're built with a high arch for easy filling without voids, tapered front to rear for fast, clean dumping.

See your Bucyrus-Erie distributor for more about these hard-working, dependable machines. He'll be glad to give you complete information.

BUCYRUS ERIE

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145E48

Robert L. Pinion, Jr., senior civil engineer in Humble Oil & Refining Company's East Texas division office, Tyler, has been promoted to assistant division civil engineer, Southwest Texas division, Corpus Christi. He replaced **Lloyd O. Zapp,** who was promoted to senior supervising engineer, Civil Engineering division, Houston office. **James L. Griffin,** district clerk, Government Wells district, was promoted to assistant district chief clerk at Scott & Hopper district. He replaced **George B. Wells,** who was promoted to district chief clerk at Government Wells. **Harry R. Barkley,** district chief clerk, Kelsey district, was transferred to the Southwest Texas division office as division material pusher. **Jack D. Brown,** civil engineer, Odessa district, West Texas division, was promoted to district civil engineer replacing **R. F. Carroll,** who was transferred to the West Texas division office as office civil engineer. **Robert A. Estes,** former office civil engineer, was promoted to assistant division civil engineer, replacing **Henry E. Meadows,** who was appointed division civil engineer. **Virgil A. Walston,** former division civil engineer, was transferred to the Civil Engineering division, Houston office, as senior supervising civil engineer. **J. R. Masterson,** district civil engineer, Friendswood, was transferred to the Gulf Coast division office as senior civil engineer. **J. F. Baehr,** office engineer, Southwest Texas division office, was transferred to the Civil Engineering division, Houston, as civil engineer. He was replaced by **O. L. Fontenot,** formerly district civil engineer in the Hub district, Louisiana division. Toolpusher **I. D. Wafer** of the Grand Isle district, Louisiana division, was promoted to assistant district superintendent of his district. **A. J. Bedford,** assistant division chief clerk, Southwest Texas division, was promoted to division chief clerk of the West Texas division, Midland.

»

Edgar A. Locke has been appointed to the new post of manager of the Exploration department of the Mid-Continent Petroleum Corporation, Tulsa. He will take charge of all geological and geophysical operations for the company, with **G. N. Smith** and **A. L. Beekly** remaining as chief geophysicist and chief geologist, respectively.

Edgar A. Locke

Before joining Mid-Continent, Locke was with The Texas Company in Denver, where he was in charge of geophysical operations in the Rocky Mountain area. After joining the Geophysical division of Texaco in 1933, he did geophysical exploration work in Texas and Louisiana until 1942.

Locke was a major in the Army Corps of Engineers during World War II. For three years he was in the Southwest Pacific as petroleum officer supervising construction and operation of pipe lines and storage tanks which supplied gasoline to the Air Force and Army. After the war he rejoined Texaco as field superintendent for the Geophysical division in Houston.

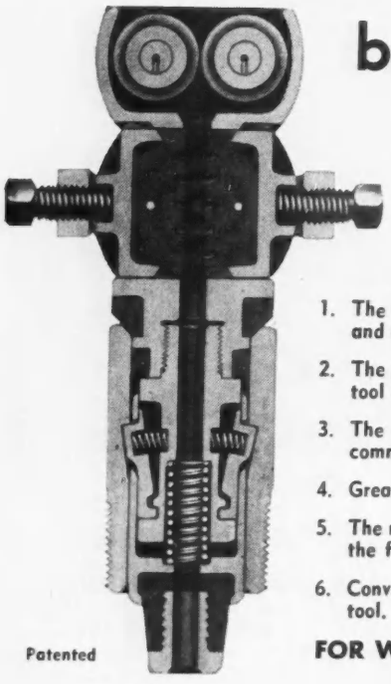
»

Edwin A. Taegel, formerly a consulting geologist, will be in charge of the Geological department of Danciger Oil & Refining Company's new district office in the Transit Tower Building, San Antonio. **Jay Hausam,** formerly associated with the company both at Tulsa and Fort Worth, is being transferred to San Antonio to supervise the Land department.

»

G. T. Buskirk, formerly division geologist at Bogota, Colombia, and **C. F. Schock,** formerly division landman at Calgary, Alberta, Canada, Stanolind Oil and Gas Company, have been promoted to division exploration superintendents of the Colombian and Canadian divisions, respectively. Each will remain in charge of the Stanolind office at his location. **Ian M. Cook** has been named a senior geologist in the Canadian division at Calgary. **Charles F. Henderson** has resigned as assistant geologist for West Texas and southeast New Mexico for Stanolind, to become a consulting geologist at Midland, Texas.

Low Maintenance
no Undue Pressure
but Be Sure IT'S A KING Be Safe



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With A 3AR Wire Line
STRIPPER FOR SWABBING TUBING

Type 3AR King Wire Line Stripper ("Oil Saver") is the ideal tool to use in connection with swabbing operations.

1. The positive latch and sure release insure against accidents and eliminate the possibility of jerking a wire line in two.
2. The packing is inserted from the sides of the tool and the tool can be repacked while the line is in the hole.
3. The roller line guides center the line; outlasts the more commonly used bushing many times.
4. Grease nipples are provided to lubricate the guide rollers.
5. The non-sparking materials used in its construction minimize the fire hazard.
6. Convenient hand holds contribute to easy handling of the tool.

FOR WIRE LINE CORING THE 4AR KING WIRE LINE STRIPPER IS WIDELY USED

The Type 4AR Stripper is similar to the Type 3AR, except it is a little larger. It is commonly used in connection with the Type 4C King Circulating Head. It can be, and sometimes is, used with other makes of circulating heads.

These tools are constantly coming into greater use. A trial is convincing.

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LESAGE INDUSTRIES
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Graham, Texas.
December 4th, 1948.

Mr. H.R.Carlson, Ass't. Dist. Mgr. Industrial,
International Harvester Co.,
1809 So. Lamar St.,
Dallas, Texas.

Dear Mr. Carlson:

We thought you would be interested in knowing what success we have had todate with International power units for oil well pumping purposes. We now have 15 of your engines working on our leases, U-2's, U-4's and U-6's.

The average lift on these wells are 4300' and with the volume of fluid to be pumped, these engines are operating on a 24 hour basis and are producing their maximum horse power.

We tried the single cylinder slow speed type engine for this work but had to go to your engine the multiple cylinder type to get this job done as we wanted it.

Some of these International power units are 3 years old and the balance have been put in service since. Our experience todate is that you have dependable power and a very serviceable engine, which we find very economical to operate.

Your power unit dealer, Turner Brothers, here at Graham, Texas are doing a **splendid** job in taking care of any service requirements we have needed.

Yours very truly,
F.J.Finch,
General Superintendent.

TELEPHONE C 2208

Like LeSage Industries, you'll find the pumping performance you need in multiple-cylinder Internationals. These engines are built to work many thousands of hours with a minimum of attention. They're designed for dependability and rigid operating economy.

When you buy pumping equipment, make sure of top-notch performance by having your supply house power it with International multiple-cylinder engines. When you need power units or engines to operate pump jacks or other oilfield equipment, see your International Industrial Power Distributor or Power Unit Dealer.

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International U-4 Gas Power Units pumping oil on the LeSage Industries lease near Graham, Texas.

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WHEEL TRACTORS
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Standardize on Power that Pays

A. W. Hair has been appointed accounting and office coordinator for the central region of Socony-Vacuum Oil Company, Inc., at Chicago. **Hugo H. Hurst** has been made central manufacturing accounting and office coordinator. Hair is responsible for all accounting activities in the central area with Hurst reporting to him.

H. J. (Harley) Holcomb of the process engineering department of the Augusta, Kansas, refinery of the Socony-Vacuum Oil Company, Inc., has been transferred to the company's Pipe Line department at 26 Broadway, New York, where he will be in charge of scheduling product movements through the lines. Holcomb started with Socony-Vacuum 20 years ago, transferring in 1939 to Augusta from the company's refinery at Casper, Wyo. He served as a major in the U. S. Army during World War II.

»

Cecil Lanier has resigned from the Magnolia Petroleum Company Land Department after 21 years and will become an independent operator. **John T. Jones** has been transferred from Midland, Texas, to Oklahoma City to succeed Lanier and **Pat Duncan** has been made landman at Midland.

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AMERICAN
RADIAL
Roller Bearings
AMERICAN RADIAL ROLLER BEARINGS are engineered to exacting standards that result in better performance and minimum maintenance.
Furnished in 5 styles, 6 S.A.E. series and 85 sizes. Special designs also available. Write.
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Ralph C. Farley has been appointed assistant to **Fred E. Smith,** general superintendent of production, The Ohio Oil Company. Farley has been district superintendent in charge of the company's offshore operations in the Gulf of Mexico. **John S. Leonard,** drilling foreman at Reed City, Mich., will succeed Farley as superintendent of operations in the Gulf.

Farley joined the Ohio in the Pipe Line department at Del Rio, Texas, in 1926. In 1931, he was transferred to the East Texas field, where he was district foreman in charge of production at Rodessa, and district foreman at Carlisle. He became division superintendent of production at Shreveport in 1944.

J. S. Leonard

R. C. Farley

Leonard joined Ohio in 1930 and for ten years was assigned to the company's operations in Mexico, where he served as a geologist and in the Production department. He was district petroleum engineer at Hobbs, N. M., and at Bay City, Texas, before becoming superintendent of the Ross Ranch, Texas, field in 1945 and drilling foreman of that field in 1947.

H. R. Bolton, division petroleum engineer, Tulsa, has been transferred to Marshall, Ill., as division petroleum engineer for the company's Terre Haute, Ind., division. Bolton joined the Ohio in 1938 at Buena Vista, Calif., first as roustabout then as an engineer. He transferred to Tulsa in 1947.

R. E. McMillen, district petroleum engineer at Midland, Texas, has been appointed to succeed Bolton as division engineer at Tulsa. McMillen became associated with the Ohio in 1941 as an engineer at Mt. Pleasant, Mich. He was named district petroleum engineer in 1942 and assistant division petroleum engineer of the Grand Rapids division in 1943. He was transferred to the Midland district in 1946.

D. V. Kitley, petroleum engineer in the Midland district, has been assigned as district engineer for Midland. Kitley started with Ohio in 1936 at Henderson, Texas, and was named assistant petroleum engineer at Henderson in 1937. He became petroleum engineer at Midland in 1947.

»

John R. McNulty has resigned as division director of personnel with the Ohio Oil Company at Casper to become manager of industrial relations for Husky Refining Company at Cody, Wyoming. He was with Ohio for 15 years and spent four years in the Air Corps doing training, personnel, and legal work.

Fine Individual Parts

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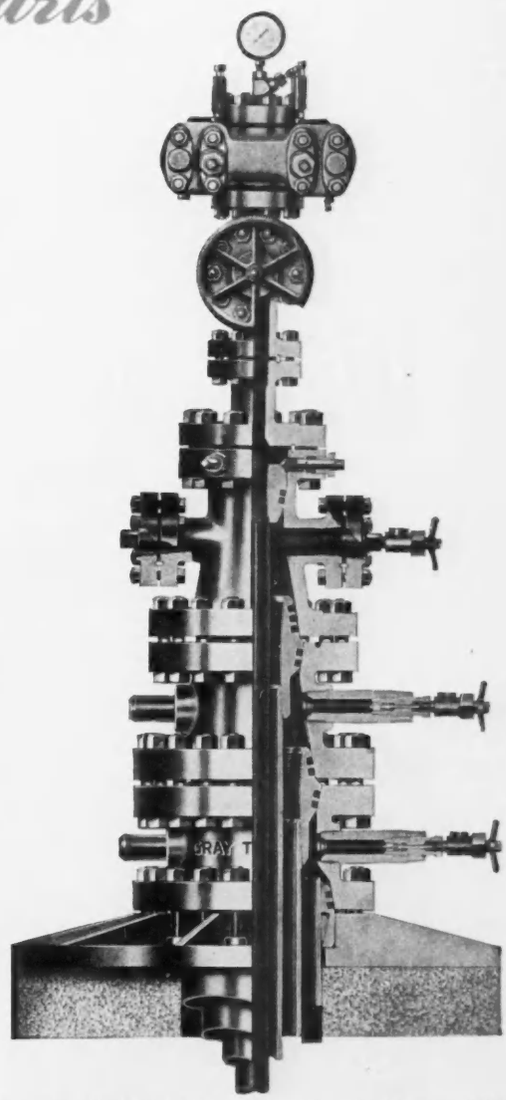
COORDINATION

Coordination of fine individual parts into a unitary whole provides the highest degree of control, economy, safety and operating efficiency for performing the entire sequence of operations from drilling through producing the well. There is no gap in control when a planned procedure is followed which considers each operation as it is to be performed, the equipment required to perform it, and the coordination and concentration of this equipment into a smooth sequence of operations.



Complete Well Head Assembly equipped with Type 3170 Composite Manifold, Valve Removal, Installation and Renewal and Boll Weevil Casing and Tubing Hangers.

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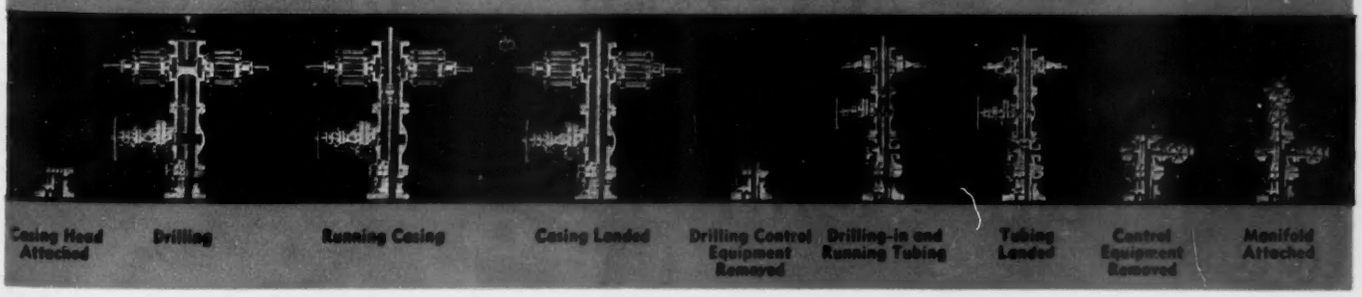


B. L. Clark, formerly with Stanolind Oil & Gas Company, Tulsa, has been named district geologist for Warren Oil Corporation at Houston. **Wesley Davis,** formerly with The Chicago Corporation, has been made district geologist with headquarters at Corpus Christi, Texas. **Richard W. Fry,** formerly with **George W. Strake,** has been made district land man at Corpus Christi. Clark joined Stanolind in March, 1941. After being discharged from the Air Corps in December, 1945, he rejoined the Stanolind organization and was reassigned to Houston. Davis worked for Shell Oil Company, Inc., for 4½ years and then joined the Empire Gas & Fuel Company. He resigned 2½ years later to join Southern Minerals Corporation at Corpus Christi, resigning after three years to become affiliated with The Chicago Corporation. Fry has had 15 years of land and leasing experience in Oklahoma, Kansas, and Texas, having worked for the Cosden Oil & Gas Company, Stanolind Oil & Gas Company, and George W. Strake.

»

Errol J. Hesser has resigned as Gulf Coast drilling superintendent for Rowan Drilling Company and is with the British-American Oil Producing Company as production superintendent for the Gulf Coast division, with headquarters at Houston.

A. E. Groff, secretary of Shell Pipe Line Corporation, is now a full-time member of the Shell Pipe Line executive staff. This change follows the decentralization of certain Shell Oil functions heretofore administered by Groff. He will continue his present duties of secretary of Shell Pipe Line Corporation and secretary of its board of directors. In addition he will become manager of the new Land, Insurance and Tax department.

A. E. Groff

Groff entered Shell's employ 24 years ago as a clerk in the Title and Rental department at St. Louis. In 1930 he was transferred to Dallas, where he served as assistant land superintendent of the old Central division. In 1933, he was appointed assistant manager of the Land department, and in 1934 he was made manager. In 1940 Groff was named manager of Shell Oil's Insurance, Tax and Claims department. In 1946 with decentralization, he became manager of the Tax-Public Relations department on the regional staff where he served until his transfer to Shell Pipe Line.

»

B. W. Letcher has been elected to the board of directors of Standard Oil Company of California. Letcher has been with Standard since 1911, when he went to work as a clerk in the Manufacturing department. He later became chief clerk in the general office, then assistant general auditor, and in 1926 was made general auditor. Letcher was elected secretary and comptroller in 1940 and a vice president in 1944. Recently, he has devoted most of his time to Standard's foreign interests.

B. W. Letcher

»

V. E. Middlebrook, manager of Shell Oil Company's gas-gasoline operations in the Mid-Continent area, has resigned to enter business for himself as an engineering consultant.

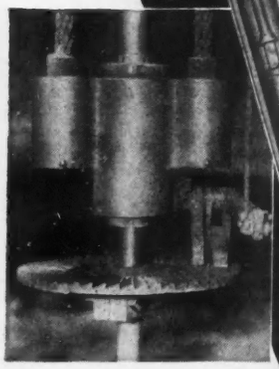
Middlebrook received his formal technical education at Texas A & M College, and since that time he has been associated with Coltexo Corporation, Phillips Petroleum Company, Texas Empire Pipe Line Company, and for the past 12 years with Shell. Middlebrook will specialize in problems relating to plant operating efficiency and in the process and mechanical design for liquefaction of the lighter hydrocarbon constituents such as butane and propane. He will office in the Citizens National Bank Building, Tulsa.

WHAT ARE YOU PAYING FOR PARAFFIN REMOVAL?

TOO MUCH — If your pumping wells are not equipped with HUBER SCRAPERS

Many major companies report Huber Scrapers have completely eliminated paraffin removal costs or reduced them to only a fraction of a cent per barrel of oil produced. Huber Scrapers, shrink-fitted to new or used sucker rods, scrape the paraffin from the tubing wall as the string rotates and reciprocates. Rods are rotated by the special Huber Rotating Rod Hanger.

Reduce or eliminate your paraffin removal costs with Huber Scrapers. Write for latest bulletin.



HUBER ROTATING ROD HANGER

This rod hanger rotates the rod string a fraction of a turn on each reciprocation. Two ratchet levers, operated by a flexible cable extending from the walking beam, engage the teeth in the turntable to turn the rod string.

Sold through supply stores.

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P. O. Box 831
BORGER, TEXAS

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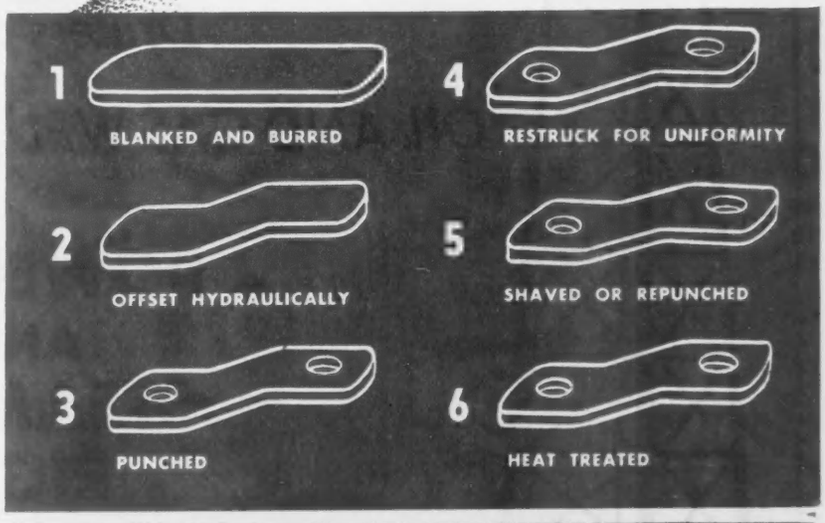
PARAFFIN SCRAPERS
SCRAPE AS THEY ROTATE AS THEY RECIPROCATE

Stronger SIDE BARS

Careful boxing assures clean chain. Easy-to-read labels facilitate handling and storage.

Here's Why:



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JM

THE JEFFREY MANUFACTURING COMPANY, 985 North Fourth Street, Columbus 16, Ohio

J. (Jack) D. Hunnicutt, former district land agent at Tallahassee, Fla., has been appointed district land agent of Shell Oil Company's new district land office at 1808 South Street, Lake Charles, La. He will be in charge of land and title work in the south Louisiana territory lying generally west of the Atchafalaya River. On February 1, Shell will open a district exploration office in Baton Rouge. **Perry S. McClure,** former district geologist at Denver, is the district geologist at Baton Rouge, in charge of exploration activities for southeastern Louisiana, comprising that part of the state lying generally east of the Atchalaya River. A new office is being constructed at 721 Government Street to house the new exploration office as well as the present Baton Rouge district land office, which is headed by **E. C. Abell.**

»

John Shawne and **Richard Nellis** have have been named landman and geologist, respectively, for The Ohio Oil Company at its new branch in Sayre, Okla., covering that section of the company's Kansas-Oklahoma operations.

DAN L. CLARK W. M. AVERILL RUPERT COX

DAN L. CLARK

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COMPANY

Drillers of

OIL AND GAS WELLS

POWER AND STEAM RIGS

WILSON BUILDING

CORPUS CHRISTI, TEXAS

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R. L. Wagner, for the past two years assistant manager of the Legal department of Shell Oil Company, Inc., New York, has been named general counsel of Great Lakes Pipe Line Company at Kansas City, Mo. Wagner has been in the Shell's Legal department since December, 1939, except for 3½ years with the Navy during the war. He joined Shell in St. Louis and worked there and in Chicago before entering the Navy.

R. L. Wagner

»

Earl B. Sloan has been appointed manager of the Gas department of the Pure Oil Company. He has been manager of the Material Control department, where he will be succeeded by **William C. White** of the company's Illinois Producing division, who is being transferred from Olney to Chicago. **William R. Waggoner** will continue in the Gas department as gas superintendent.

»

G. R. Preston has been named manager of the Economics department, Cities Service Oil Company, with headquarters at Bartlesville. Preston attended Oklahoma A. and M. College and joined Cities Service in March, 1925. Five years later he was appointed budget manager and in 1940 was elected assistant treasurer. He will continue to head the company's program for acquiring producing properties.

G. R. Preston

»

Kenneth W. Haley has joined Deep Rock Oil Corporation as chief engineer in the Production division, replacing **C. O. Moss,** who was made assistant to the vice president on special assignments. Haley was previously associated with Barnsdall Oil Company and Standard Oil Company of California.

»

Edward L. Zihlman of Wichita Falls, Texas, has been promoted to assistant division land and leaseman at Fort Worth, West Texas Division, Producing department, The Texas Company. Zihlman, who has been district landman at Wichita Falls, started with the company as an office boy in 1926. After working as a clerk in Fort Worth, he was made a scout at Wichita Falls in 1937. Having advanced in scouting and leasing operations at Midland, Wichita Falls and Abilene, in 1942 he was named scout-leaseman at Abilene, and a year later was appointed district landman at Wichita Falls.

»

Andrew Vaught has been made tool pusher for Williams-Copeland, Inc., drilling contractors and producers of Tulsa.

For more service in your well...
Less servicing at the surface!

Specify Pacific
Precision Built Oil Well Plunger Pumps

Require Less Servicing at the Surface Because
of Maximum Protection for the Critical Zone
By Selecting Materials for

Plungers · Liners · Valves
Valve Seats · Valve Cages

To resist corrosion and finished with the
hardness necessary TO RESIST ABRASION AND WEAR.

Pacific Oil States Sectional Liner Pumps

TRAVELING PLUNGER TYPE

TRAVELING BARREL TYPE

Built to API Standards
with Pacific Precision Finish

PACIFIC
Precision Built
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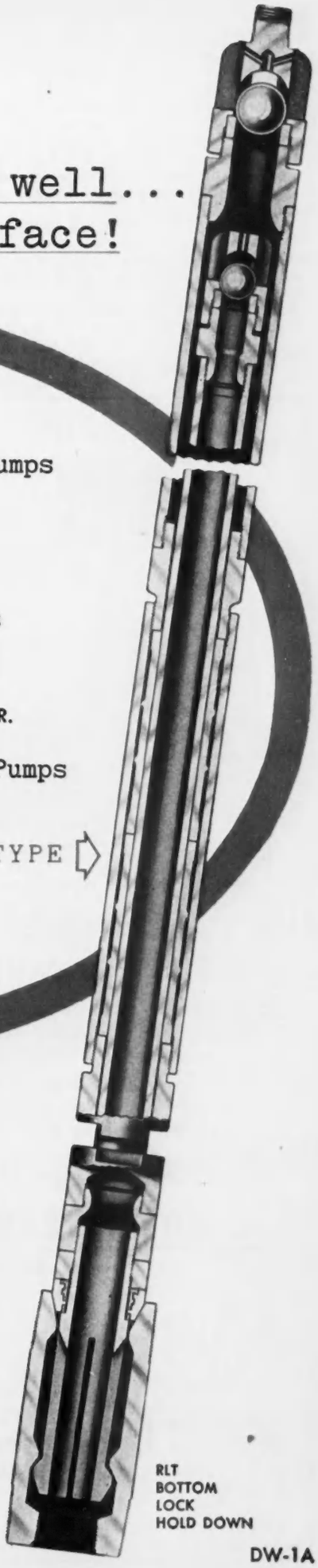
Export Office: Chanin Bldg., 122 E. 42nd St.
New York, N. Y.
Offices in All Principal Cities



RLA
TOP
LOCK

RLT
BOTTOM
LOCK
HOLD DOWN

DW-1A

Raymond J. Lowe, 45, assistant purchasing agent for The Pure Oil Company at Tulsa, died February 1, after a heart attack. He had been with the firm 25 years and a Tulsa resident since 1925. During World War II he was in the Army Air Force and was discharged with the rank of lieutenant colonel. At the time of his death Lowe was adjutant of the 340th Light Bomb Group, Air Reserve.

»

Paul M. Brown, veteran employe of the Tide Water Associated Oil Company, died February 13, in a Tulsa hospital after a lengthy illness. He had been associated with Tide Water in the accounting department for 29 years and had resided in Tulsa since 1907.

DEATHS

Gustaf L. Kollberg, 70, retired Allis-Chalmers Company executive, died February 2 in Milwaukee. Kollberg was connected with the engineering, designing and installation of high presure and oil pipe line pumps, and the early development of the centrifugal pump. In 1897, he joined the Fraser and Chalmers Company as a draftsman. The firm became a part of Allis-Chalmers in 1901. He continued with Allis-Chalmers until his retirement in March, 1944, at which time he was manager of the company's Blower and Compressor department.

George W. Wells, 66, comptroller for the Superior Engine division of the National Supply Company, Springfield, O., died January 16. Wells had been associated with National Supply for 45 years at the company's Toledo plant and at the company's executive offices in Pittsburgh before being transferred to Springfield.

»

J. Ernest Thompson, 63, partner in the firm of Thompson & Thompson, independent operators, died January 30 in Houston.

»

Harry L. Mourer, 65, president of the Crude Oil Corporation of America, Tulsa, died February 9 in Tulsa, after a heart attack. At one time he was president of the Oklahoma-Kansas Oil Company and operated extensively at Burkburnett, Texas.

»

Ernest C. Cortelyou, assistant superintendent of production for Cities Service Oil Company, died January 20 in Oklahoma City.

»

Lee Koen, 65, former owner of W-K-M Oil Field Supply Company, Houston, died February 4 at Houston.

»

Edward Templeton Moore, 82, a director of the American Petroleum Institute and formerly president of Mid-Continent Oil and Gas Association, died February 4 at Dallas. At one time Moore was president of Simms Oil Company.

»

Ralph D. Risser, 56, former division superintendent, Shell Oil Company, Inc., died February 6 at Kilgore, Texas.

»

James W. Starks, 67, director of the Illinois State Department of Mines and Minerals, died February 3 in Springfield, Ill.

»

Smith H. Lapsley, 51, of Tulsa, pipe line engineer with the Texas Pipeline Company, died February 14. He had been with Texas Pipeline Company since 1936 and was previously associated 12 years with Cities Service (Empire) Oil Company at Bartlesville, Okla.

»

Albert James Squier, 75, former president of the Oil Trades Association of New York, died February 10 in Scranton, Penn.

»

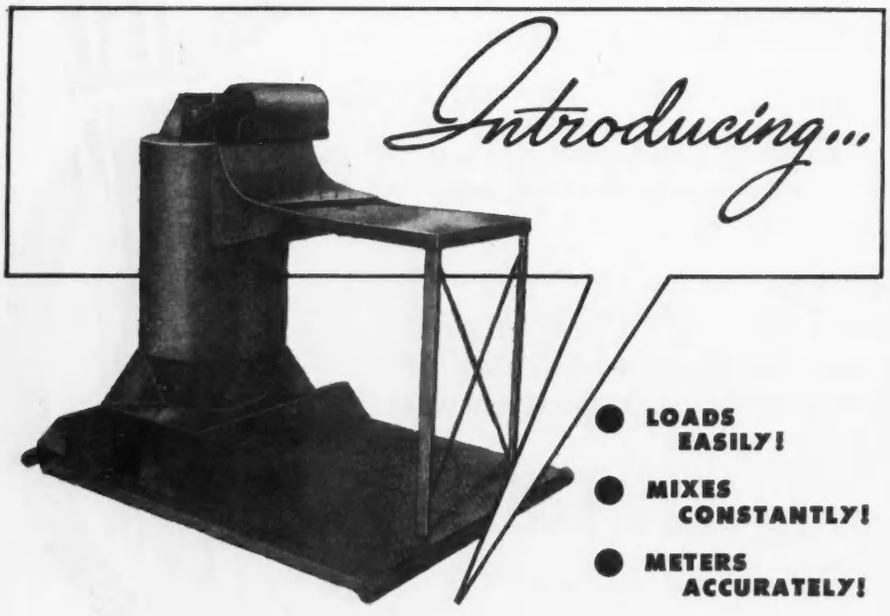
Tronson Draper, 70, veteran Canadian oil man, died in Arizona. For many years he was associated with the Royalite Oil Company, Calgary.

»

Dr. Bailey Willis, 91, internationally known seismologist and geologist, died February 20 at Palo Alto, Calif. Dr. Willis was the author of two autobiographical works, "Yanqui in Patagonia" and "Friendly China."

»

Floyd Cummings Dodson, 53, geologist and independent oil operator of San Angelo, Texas, died January 29 in San Angelo.



THE EMPIRE METERING MUD MIXER!

DRILLING MUD SAVER DELUXE

This Mud Mixer, with patented METERING outlet, is like money in the bank! Drilling contractors will find it cuts mud mixing time at the well, for a faster job with more profit! The Empire METERING Mud Mixer is light . . . easy to hook up and move . . . made for AC or DC current. It eliminates mud pit settling of expensive drilling mud . . . accurately controls the AMOUNT of mud used . . . cuts drilling time and fishing jobs . . . puts a better coating in the well . . . and costs only $660.00!

A POSITIVE MUD ECONOMIZER

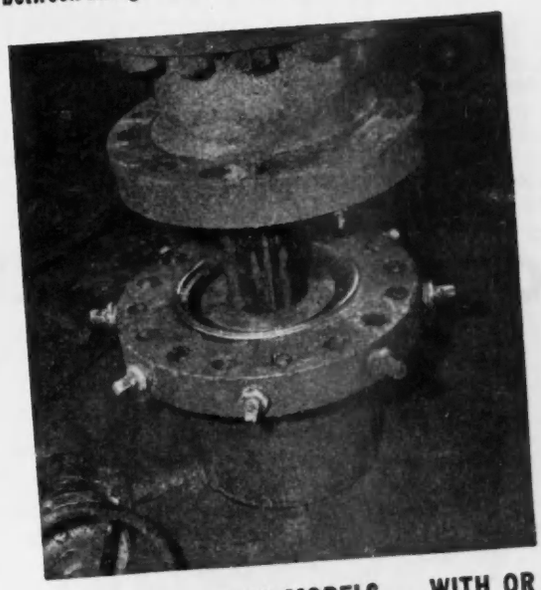
WRITE FOR COMPLETE DESCRIPTION

FLEXIBILITY *plus!*

ONLY THE O-C-T C-19 MEETS EVERY WELL COMPLETION CONDITION WITH A SINGLE COMPACT MODEL

SET IT LIKE THIS

The O-C-T "C-19" Casing Hanger is the only slip type hanger that can be wrapped around the casing and seated through the preventers to form automatically a permanent seal between strings before the preventers are unflanged.



OR SET IT LIKE THIS

If pipe sticks, a collar is located in the blowout preventers, or rams freeze partly open, the preventers may be picked up in the conventional manner and the C-19 hanger wrapped around the pipe and seated in the head to give a permanent seal in a fraction of the time required by a conventional hanger.

AVAILABLE IN TWO MODELS . . . WITH OR WITHOUT LOCK SCREWS.

PLUS THESE OTHER O-C-T FEATURES

1. Load capacity twice as great as conventional slip hangers. Will swing full weight of longest strings without mashing pipe.
2. Sealing element, slip bowl and slips are assembled as a single unit.
3. Slips set evenly—heavy keys align slips so tops are level.
4. Slips bite evenly—tooth pressure is uniform from top to bottom.
5. The seal is automatic when casing weight is applied. No manual work required.
6. Seal requires no field welding.
7. Hazardous installation work in muddy and cramped cellar space reduced to minimum.
8. Saves valuable rig time.

NO OTHER CASING HEAD GIVES YOU O-C-T FLEXIBILITY AND SAFETY

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Export Representatives:

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to P. O. Box 3091, Houston 1, Texas.

EQUIPMENT AND SERVICE SUPPLIERS' NOTES

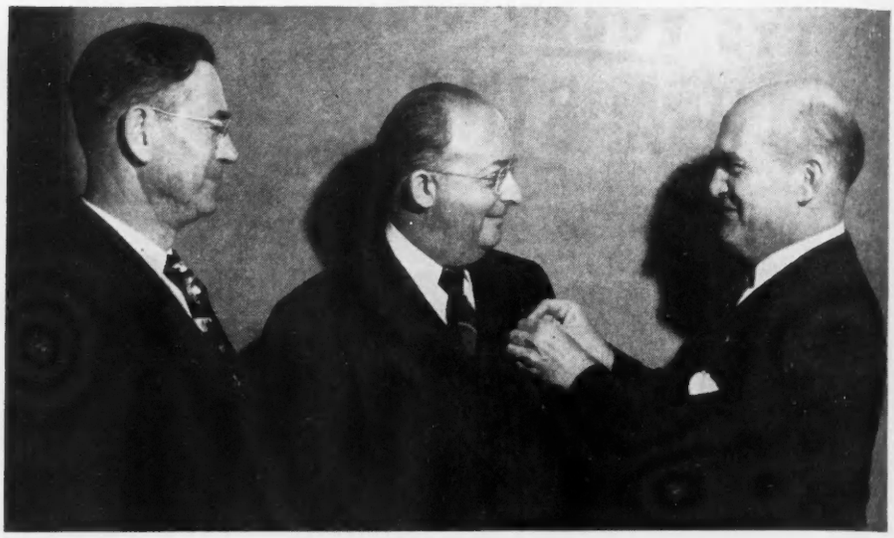
Technical Oil Tool Appoints Rocky Mountain Representative

P. T. Bannerman, service and sales engineer of Technical Oil Tool Corporation, Ltd., will represent the company in the Rocky Mountain area. For the past three years Bannerman has represented Totco in foreign fields, including South America, the Caribbean area, Mexico, fields in the Near and Middle East, and oil company head offices in Europe. Bannerman's headquarters will be in Cody, Wyo.

Los Angeles Office of Chain Belt Company Moves to New Quarters

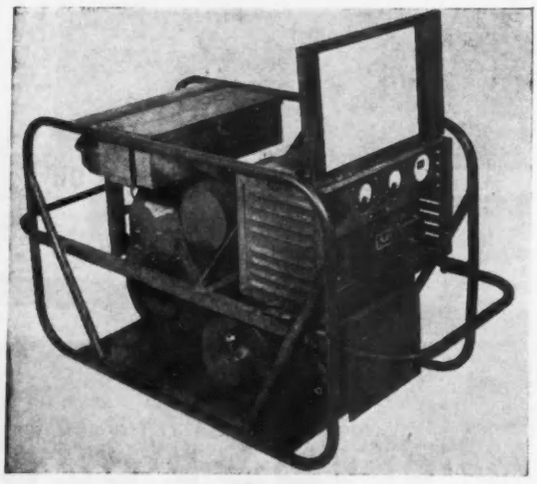
Chain Belt Company of Milwaukee has moved its Los Angeles district office and warehouse to new and larger quarters at 3838 Santa Fe Avenue, Los Angeles 11. J. V. MacDonald, district manager, will continue in charge of the new warehouse and district office.

New facilities for the machining of sprockets, shafting, shaft couplings and other power transmission items now supplement warehouse stocks of these items.



RECEIVE SERVICE AWARDS—The Continental Supply Company presented service awards to 27 men of the Gulf Coast district who have completed from five to 32 years of service. N. A. Endicott, center, vice president in charge of the Gulf Coast area, who has had 32 years of service, presided at the meeting. Service pins were awarded by F. M. Mayer, right, president. A. B. Mhoon, left, has been with Continental 28 years.

PORTABLE ELECTRIC POWER AT A LOW PRICE



1000 Watts
•
HEAVY DUTY
•
Completely PORTABLE
•
Carry it anywhere (300 lbs.)

$110.00 EA.

F. O. B. PHILA.
Government Cost $482.00

SPECIFICATIONS

ENGINE—Briggs & Stratton, air-cooled, 2.75 H.P. at 2400 R.P.M.

GENERATOR—Leland, develops 1000 Watts, 1 Phase, 115 Volts, AC current, or 700 Watts and 115 Volts AC plus 300 Watts at 14.6 Volts DC current. All instruments and voltage regulation.

These plants are all practically brand new; were stored outside, have been gone over in our shops and are fully guaranteed.

Also available immediate shipment at marked reductions—Generating Plants, Gas and Diesel in All Capacities up to 25 KW. Write us your requirements.

Ask anyone who has dealt with us.

PETER COOPER ASSOCIATES

5600 OGONTZ AVE. PHILADELPHIA 41, PA.

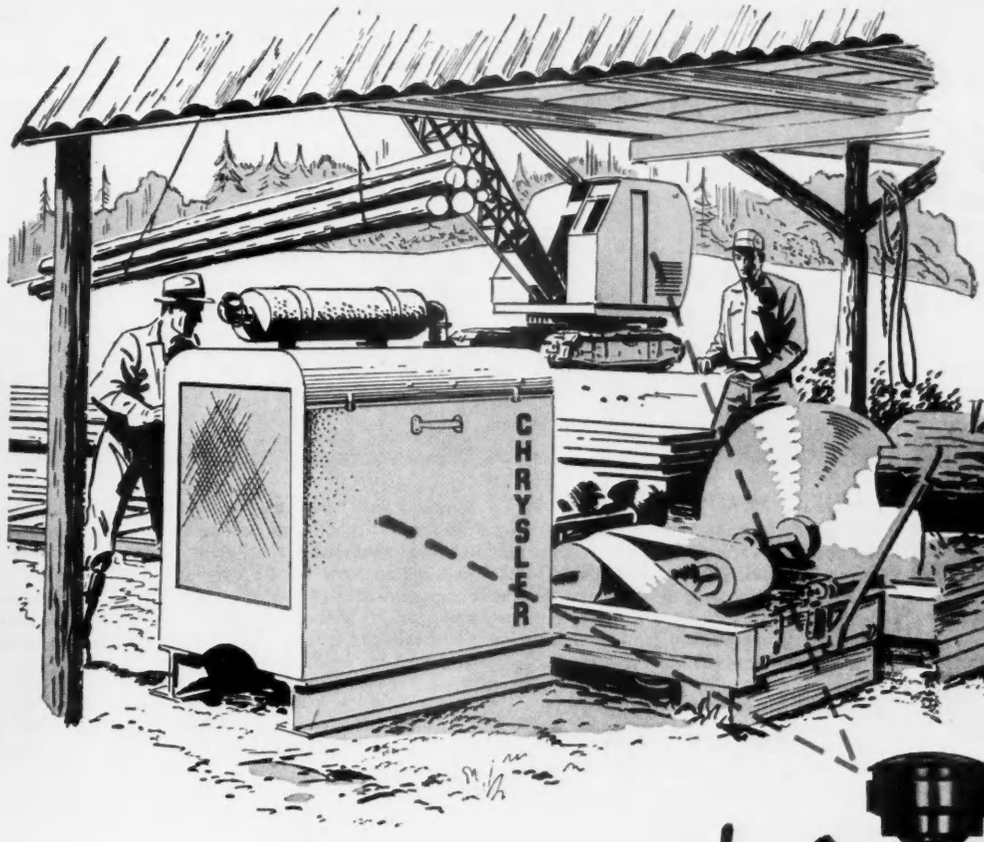
Oil Well Supply Company Appoints New Chief Industrial Engineer

Gordon M. Amstutz has joined Oil Well Supply Company as chief industrial engineer. He will be located at the Imperial Works, Oil City, Penn. Amstutz was graduated from Ohio State University in 1927 with a Bachelor of Science degree in electrical engineering. Afterwards he served as a time study engineer for the B. F. Goodrich Company at Akron, Ohio, and later as an industrial engineer with the Reliance Electric and Engineering Company of Cleveland. From 1934 until 1946, Amstutz was connected with the Armstrong Cork Company, first at Lancaster, Penn., and for the last four years at Beaver Falls, Penn., where he was manager of that company's plant.

Gordon M. Amstutz

M. O. Johnston Oil Field Service Company Promotes Norman Andrew

Norman K. Andrew has been appointed assistant to W. F. Bettis, manager of M. O. Johnston Oil Field Service Company. Andrew has had 15 years' experience with various types of service tools in California, Texas, Louisiana, Arkansas, and Kentucky, and was formerly an instructor in the College of Engineering at the University of Southern California.



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in forests—

IN INDUSTRY—IN OIL FIELDS—ON FARMS—AND ON THE HIGHWAYS!

● **The logging industry delivers record cuttings year after year . . . tremendous output figures made possible by careful planning and efficient, dependable power. Chrysler Industrial Engines and Power Units provide smooth, economical horsepower for sawmills, generators, air compressors, industrial mobile units, cranes and other logging equipment. For information about the full Chrysler Industrial line and its applications in all fields, write . . .**

INDUSTRIAL ENGINE DIVISION, CHRYSLER CORP.
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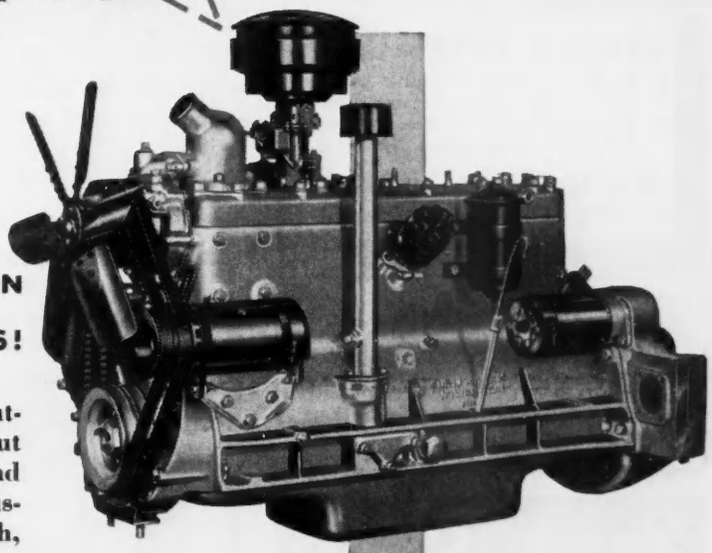


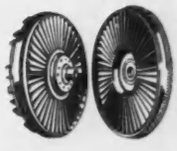
MODEL INDUSTRIAL 14
SIX CYLINDER

Bore 3¾". Stroke 5". 331.4 cubic inches displacement. Engine assembly equipped with truck type clutch housing, 20" suction type fan, hot type oil bath carburetor air cleaner, carburetor with built-in velocity type governor, oil filter with removable type cartridge, and 6-volt electrical equipment. Generally used in powering snow shovels, industrial mobile units, sawmills and air compressors.

CHRYSLER

INDUSTRIAL ENGINES AND POWER UNITS

HORSEPOWER WITH A PEDIGREE



MODELS AVAILABLE WITH *gyrol* FLUID COUPLINGS

QUICK TURBINE REPAIRS

If you need dependable Turbine repairs *in a hurry*, call us. We are completely equipped to repair and dynamically balance turbine rotors and any High Speed rotating elements in our modern shops.

25 Years Successful Experience

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Standco NO-SMOKE

STANDCO BRAKE LINING

Nothing novel—no bunk, but it gets the job done without scoring brake rims. See pages 3973-3978 Composite Catalog.

Standco Brake Lining Co.

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Analysis of oil field brines, cores, gas, oil and minerals. Field gas testing. Long Distance 138. 823½ Monroe Street, Fort Worth, Texas.

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Established 1928

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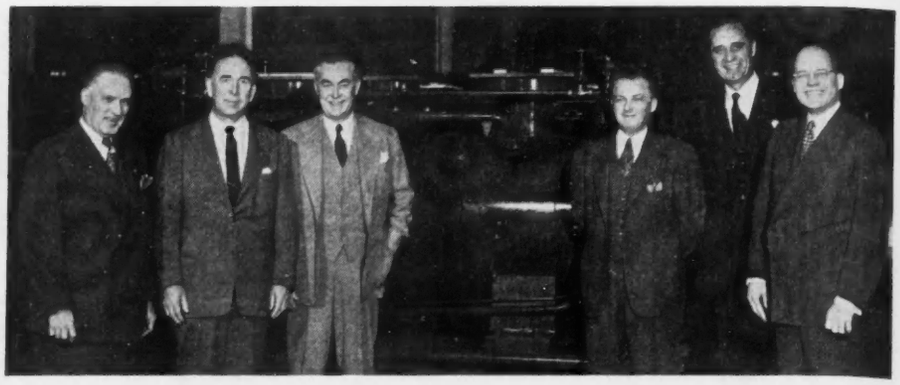
EQUIPMENT and SERVICE SUPPLIERS' NOTES



PACIFIC PUMPS ANNIVERSARY—Pacific Pumps, Inc., of Huntington Park, Calif., one of the Dresser Industries, is celebrating its 25th year of specialized service to industry. Observing the occasion were officials of Dresser Industries, Inc., who visited the Pacific plants and manufacturing facilities. Left to right are Arthur R. Weis, president of Pacific Pumps; William A. McAfee, Dresser director; John B. O'Connor, executive vice president of Dresser; Elmer J. Weis, vice president of Pacific; Prescott S. Bush, director; and Neil H. Mallon, president of Dresser Industries. Specialized engineering for individual service is illustrated by the Multi-Stage pump in the background, which has three discharge outlets, each for a different capacity and pressure.

Sales Engineer in Tournarope Sales Department Is Appointed

Charles L. White has been appointed sales engineer in the Tournarope sales department for R. G. LeTourneau, Inc., Peoria, Ill. He will be the company's representative in Texas, New Mexico, Arizona, Colorado, Utah and Oklahoma for Tournarope applications and sales. His headquarters will be at Fort Worth.

Before joining LeTourneau, White was with Bridgeport Machine Company, Wichita, Kansas; Williamsport Wire Rope Company, Williamsport, Penn.; and Bethlehem Steel Company, at Houston.

Macwhyte Representative Named

H. S. Dershimer has joined Macwhyte Company, manufacturers of wire rope, as direct factory representative with headquarters in Tulsa. He will travel in Oklahoma and parts of Arkansas, Kansas, and Wyoming.

Jefferson Malleable Unions

STYLE "B"

JEFFERSON Style "B" three-piece flange union is made with brass-to-iron and iron-to-iron seats. Being made of highly refined AIR FURNACE iron, it assures you of lightweight construction, perfect ball joint, and positive seating arrangement, whether or not in alignment.

★ ★ ★

HYDRAULIC PRESSURE RATING

Sizes	Test Pres.	O. W. G.	S.W.P.-550 Deg.
½" thru 4"	2000#	800#	250#
5" and 6"	1200#	500#	250#
8" and 10"	1000#	400#	250#

Malleable iron used in all JEFFERSON unions meets ASTM-4733, Grade 35018—M. T. 53000 Lbs., giving 75%-more elongation 50%-more impact value and is 30%-stronger than cupola malleable iron.

Obtainable through your jobber

Jefferson Union Company, Inc.

691 West 26th St., New York 1, New York

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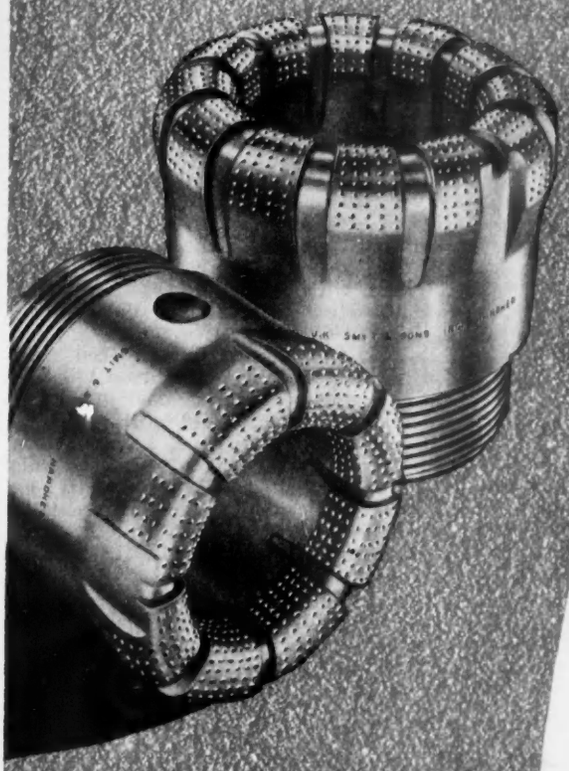
31 Fletcher St., Lexington, Mass.

Now.. HARDHED DIAMOND DRILL BITS *in the Oil Fields...*



Established in 1888, J. K. Smit & Sons are among the pioneers in the manufacture of diamond bits.

The patented HARDHED Diamond Drill Bits, for many years the standard of the mining industry, are now available for oil well drilling.

Exceptional performance has been proven during the past two years in the Texas oil fields and they are now offered for coring all formations with the assurance that they will give entire satisfaction in every respect.

Carefully selected diamonds are set in a tough alloy matrix, which effectively resists the most abrasive drilling fluids.

HARDHED Drill Bits reflect new design and improved manufacturing methods, all aimed at increasing the high level of reliability for which JKS diamond products are noted.

We are now prepared to place the experience so gained, at the disposal of oil well drilling opertors through our distributors. JKS engineers are on call to assist them in the effective application of this improved drilling technique.

Core barrels avilable for sale or rent. For prompt service contact nearest distributor.

1888 — SUPER MATERIAM IGNIS TRIUMPHANS — 1949

61 Years of Progress

J. K. SMIT & SONS, INC.

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DIAMOND OIL WELL DRILLING CO.
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EASTMAN OIL WELL SERVICE CO., LTD.
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CALGARY, ALTA., CANADA

H. C. Risner

W. F. Behrhorst

O. W. Frogge

Walt McCharen

E. H. Royle

P. L. Gillis

American Iron & Machine Works Makes Sales Personnel Changes

The American Iron & Machine Works Company has appointed Herbert C. Risner sales representative for the state of California, replacing W. F. Behrhorst, who has been transferred to Odessa, Texas. Risner has been connected with the Sargent Engineering Corporation and the Deep Well Sucker Rod and Pump Company for over 12 years in sales and service work.

Behrhorst will work out of the Odessa district sales office. Prior to spending one year in California, Behrhorst was sales representative in Kansas. He has been with the company for six years. He was formerly with Oilwell Supply Company and Bethlehem Supply Company.

O. W. Frogge has recently been added to the sales department of American Iron & Machine, and will work as sales representative out of the Houston district sales office. He was formerly with the Eastman Oilwell Survey Company, Phillips Petroleum Company, and operated his own crews for installation and removal of tool joints. He was also driller for various drilling contractors.

Herman Lawson

A. G. Pullen

Walt McCharen, who recently transferred to the sales department, will make his headquarters at Hobbs, N. M. He was formerly in the Engineering department and chief inspector at the main plant in Oklahoma City. He has been with the company for three years.

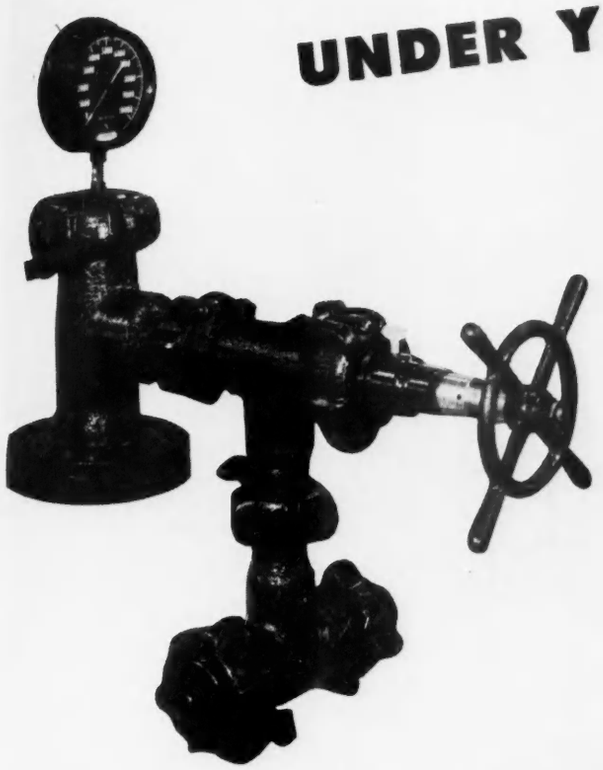
E. H. Royle has been promoted to district manager for South Louisiana and Mississippi, with headquarters in New Iberia, La. He succeeds Austin Brashears, who was recently killed in an automobile accident. For three years Royle was sales representative in North Texas with headquarters in Wichita Falls. He has been with the company since 1936.

P. L. Gillis, formerly with Reed Roller Bit Company and Halliburton Oil Well Cementing Company, has joined the sales department, and will make his headquarters in Houma, La.

A. G. (Andy) Pullen, formerly rental yard manager at Oklahoma City, has been transferred as sales representative to North Texas and will make his headquarters in Wichita Falls. He succeeds Royle.

Herman Lawson has been transferred from the Oklahoma City main plant as sales representative for East Texas and North Louisiana. He will make his headquarters in Longview, Texas.

How to keep production UNDER YOUR THUMB:



1

ASSEMBLE YOUR CHRISTMAS TREE WITH A UNIBOLT FLOW MANIFOLD

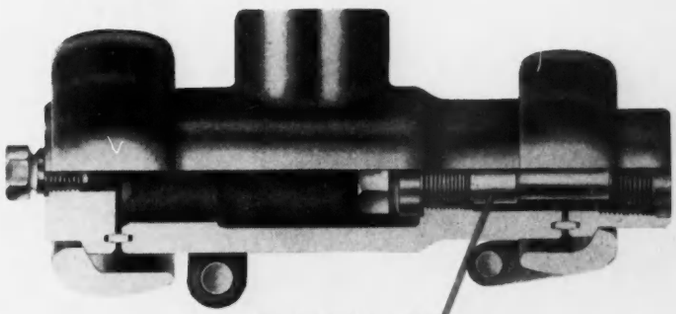
In this strong, light-weight, low-cost manifold, assembled and tested as a unit at the factory, you have every fitting essential to safe and dependable well flow control: The 3" UNIBOLT Tee (or Cross if desired) accommodates standard lubricators; the UNIBOLT Adjustable Wing Valve does the job of a conventional gate or plug valve (its 1" opening is ample to assure un-restricted flow); and the UNIBOLT Choke Body with one-bolt Blanking Plug, fitted with a positive bean, makes quick work of choke changing. The 5000 and 10,000 lbs. w.p. manifolds are available in special corrosion-resistant alloy; 3000 to 5000 lbs. w.p. units are of carbon steel.

2

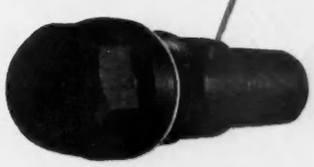
ALWAYS SPECIFY UNIBOLT "FLOW-RATED" BEANS FOR PRECISE CONTROL OF FLOW

Having pioneered practically all improvements in positive chokes, or flow beans, in recent years — close tolerance drilling of orifices, "X" Beans or orifices drilled in increments of 10% and 5% of well flow for extremely accurate control of production, and, the most recent advancement, flow-rated beans to assure a given rate of fluid flow under given pressures—UNIBOLT Positive Chokes, or Flow Beans, provide the ultimate in controlling well production.

Complete details are carried in your Composite Catalog, or descriptive literature will be gladly sent on request.



UNIBOLT CHOKE BODY



UNIBOLT MASTER BEAN

UNIBOLT INSERTS

UNIBOLT

THORNHILL-CRAVER COMPANY • HOUSTON, TEXAS

SKF Industries, Inc., Appoints C. S. Gotwals Quality Manager

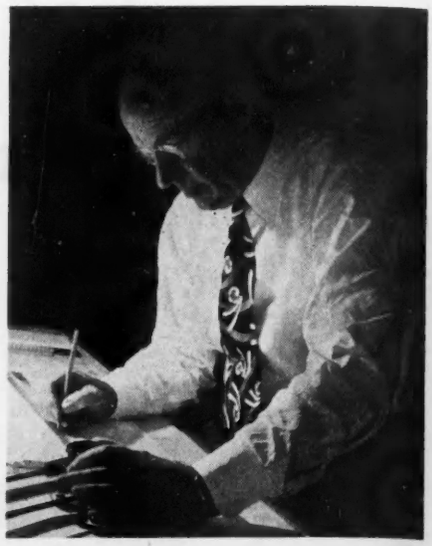
C. S. Gotwals has been appointed quality manager of all SKF Industries, Inc., plants. Gotwals was instrumental in installing SKF's quality control system during World War II and served as chief of inspection and quality control prior to becoming superintendent of the main plant of the ball and roller bearing firm in Philadelphia. He has been associated with the company since 1915.

Charles R. Scott, Jr., in charge of the machining division since 1946, succeeds Gotwals as superintendent. W. F. Shedinger will direct operations of the machining division in addition to his duties as head of the ball division.

Wickwire Names Representative In Mid-Continent Oil Areas

E. L. Klingler, assistant wire rope sales manager, Wickwire Spencer Steel Division, The Colorado Fuel and Iron Corporation, will direct the sale of Wickwire rope in the Mid-Continent area, including Houston, Abilene, Texas, and Tulsa. He previously operated out of the Palmer, Mass., sales office. Klingler has a background of 19 years in the wire rope industry, including production, engineering and sales.

THE LITTLE PUMP WITH A THOUSAND USES!
MODEL 37 ON THE JOB!
"The handiest pump we've got" is how they describe this little giant of dependability, pictured above—CMC Model 37 on the job for Olson Drilling Company at TXL Field, Eaton County, Texas.
Whether your pumping needs call for 3,000 or 200,000 gallons per hour, there is a CMC Dual-Prime pump that will handle the job right! Our engineers are at your service! Write us for details.
CONSTRUCTION MACHINERY CO'S.
WATERLOO, IOWA, U.S.A.
1903 Blodgett St., Houston, Texas
TELEPHONE HADLEY 3988



KOBE PRESIDENT—C. J. Coberly, president and general manager of Kobe, Inc., observes his company's 25th anniversary at the drafting table in his office.

Kobe Observes 25th Anniversary As Hydraulic Pump Manufacturer

Kobe, Inc., manufacturer of hydraulic oil well pumping equipment, is observing its 25th anniversary. Started in a small shop in Los Angeles, the company has made many contributions to the improvement of oil country equipment and operations, including hydraulic free pumping, introduced late in 1947.

Free pumping makes possible the surfacing and seating of the bottom hole pump by the turn of a valve, eliminating special pulling equipment and pulling crews. The design for the pump, and the system of which it is a part, came off the drafting table of Kobe's president and general manager, C. J. Coberly, as have such items as an oxyacetylene torch cutting method for slotting screen casing, hydrogen porosimeter, method of prepacking oil well liners, gas operated oil well pumping unit, and hydraulic oil well pumping.

The designing and building of a machine driven cutting head, equipped with multiple jets, to slot pipe, put Kobe, Inc., in business 25 years ago. The company later placed its major emphasis on the development and expansion of hydraulic oil well pumping.

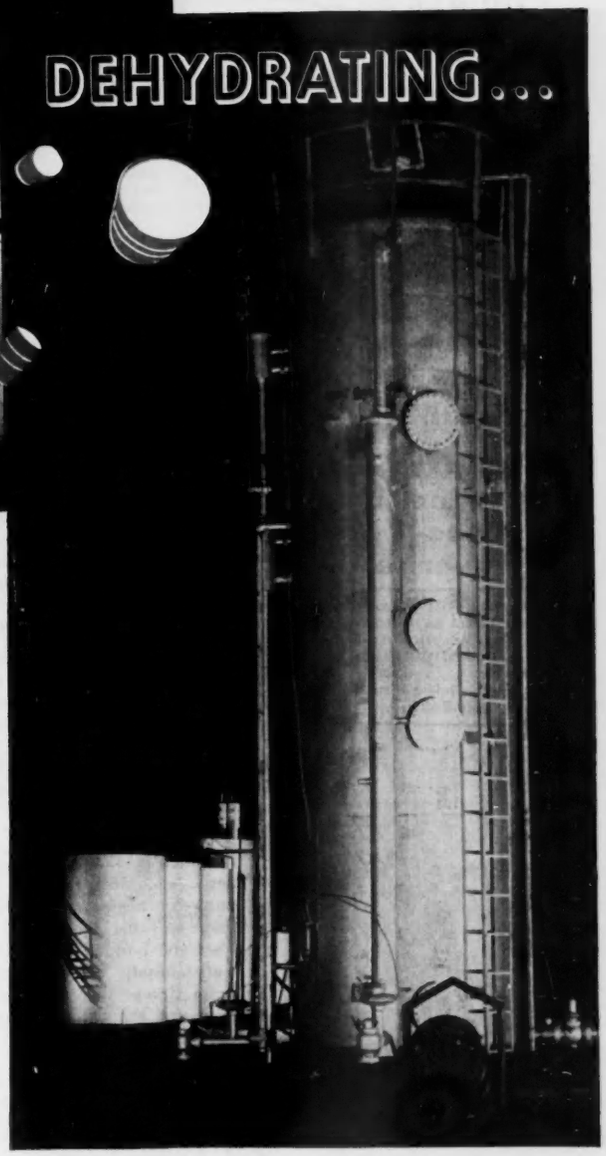
During World War II, the company's machining equipment was converted to making star gauges for the Navy. This delayed the development of the free pump, first designed by Coberly in 1934 and field tested as early as 1939.

Walter Dannenbaum Becomes Vice President of du Pont

Walter Dannenbaum was elected a director, vice president, and member of the executive committee of E. I. du Pont de Nemours & Company. He has been general manager of the company's Ammonia Department since July, 1946. He succeeds E. B. Yancey, who died October 24.

Dannenbaum has been connected with the du Pont company since it acquired the National Ammonia Company, of which he was then president.

Visco CONSISTENTLY EFFICIENT EMULSION BREAKING



VISCO PRODUCTS COMPANY
INCORPORATED
City National Bank Building
Houston 1, Texas

Visco DEHYDRATING AND DESALTING CHEMICALS • WHEREVER COST AND EFFICIENCY COUNT

NOTICE: Visco Products Company is authorized to manufacture and sell Visco Oil Treating compounds for use in the breaking and resolving of oil emulsions, and to grant licenses for such use, under the following United States patents: 1,860,562; 1,860,563; 1,912,330; 1,927,359; 2,050,639; 2,050,640; 2,206,589; 2,214,782; 2,214,784; 2,225,189; 2,303,414; 2,307,813; 2,318,034; 2,318,035; 2,321,056; 2,336,654. Re. 20,717 and patents pending. Any purchaser of Visco Oil Treating compounds is authorized to use the same in the treating, breaking and resolving of oil emulsions in accordance with the above patents. The royalty for such use is included in the purchase price. Visco Products Company is authorized to and is willing to grant licenses on a royalty basis, to all companies, and to others desiring to practice the patented subject matter, under any and all of the above patents, permitting the user to purchase the oil treating compounds at will from any vendor, and to prepare the compounds for use under the above patent or patents, at a royalty charge of 20 cents per gallon. Application for license should be made to **Visco Products Company**, Houston, Texas.

Managers Are Appointed for Six Mack Trucks, Inc., Districts

J. E. Donovan has been appointed manager of the Mack Trucks, Inc., San Francisco branch, the largest of Mack's 67 direct factory branches. Donovan, who has been with the company 25 years, was formerly special sales representative in charge of national and fleet owner accounts in the San Francisco area.

Other recent appointments include J. W. Biggins, district manager of the Louisville branch; H. J. Fikejs, district manager of the Kansas City branch; T. J. Colter, district manager of the Milwaukee branch; A. P. Cowles, district manager of the Springfield, Mass., branch; and R. J. McGivney, district manager of the Worcester, Mass., branch.

Plastic Coating Corporation Elects T. S. Maffitt President

T. S. Maffitt, Jr., has been elected president of Plastic Coating Corporation. W. Ratliff Walne was chosen executive vice president and general manager of the organization. George E. Ross and Stewart D. Beckley were named vice presidents, and Ernest S. Walne was elected secretary-treasurer.

New Acme Cable Tools

TRUSTWORTHY SINCE 1900

Acme 18" B. & R. Safety Wire Line Drilling Clamps —for wells deeper than 3000'. (See Fig. 103)

Also: Acme 12" Clamp (see right) for shallow wells, not over 3000'.

10 Simple Parts... Perfect a 9-to-1 Favorite

See Acme's latest Catalog and Manual in Composite Catalog (Vol. 1). Or mail penny postal TODAY for your copy . . . chock-full of valuable information for every Cable Driller.

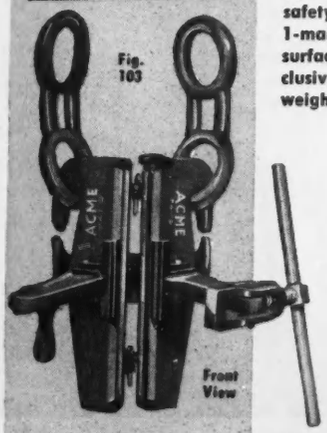
Yes, it's 9-to-1 they're Acme W. L. Drilling Clamps used east of the Mississippi . . . a proud record, built upon the QUALITY that assures greater service and safety.

Their 10-simple parts . . . fashioned of uniform, rigid specification, premium-grade steel . . . correctly heat-treated in our electrically controlled furnaces . . . for super-load carrying stamina . . . are the proven REASONS why.

Acme's 18" (deep well) Clamp weighs only 173 lbs. 200-ton breaking load . . . 6-to-1 safety factor. Non-fouling safety links. Perfectly balanced for 1-man hitch-on. 25-ton load gripping surface. Our 12" Clamp has same exclusive features, for 15-ton loads . . . weight, 160 lbs.

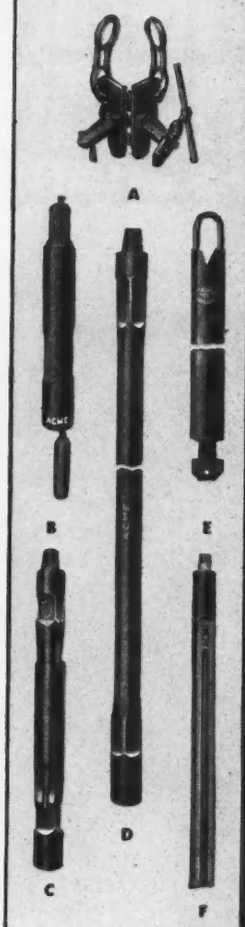
It's their EXTRA inner-qualities . . . steel to exacting analysis, engineered perfection, patented features, and 49-years' backlog of master-craftsmanship . . . that make Acme Clamps the 9-to-1 favorite and your No. 1 Trustworthy Buy.

Fig. 103



See other Acme Drilling Tools in panel (right) . . . for more of EVERYTHING you need in a Trustworthy String.

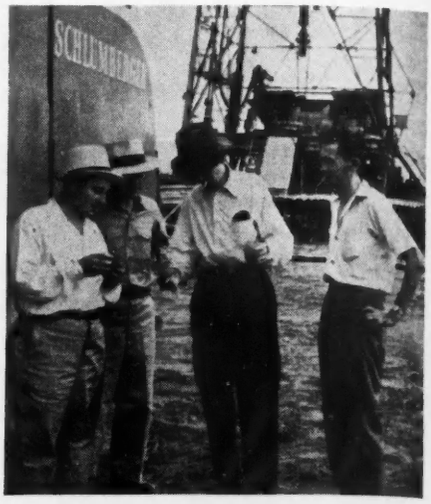
More of EVERYTHING You Need in an Acme String . . .



A—Wire Line Clamp, 12"
B—Prosser Swivel Socket
C—Drilling Jar
D—Drilling Stem
E—Bailer
F—Drilling Bit

Acme Fishing Tool Co.
PARKERSBURG, W. VA.
Export Office: 19 Rector St., New York 6, N. Y.

ACME DRILLING & FISHING TOOLS
Since 1900



NEAR EL TIGRE IN EASTERN VENEZUELA—M. Schlumberger, co-founder of Schlumberger Well Surveying Corporation, made a first-hand field inspection during a recent trip through active areas in Venezuela of one of the new Schlumberger units operating in Eastern Venezuela oilfields. Left to right: W. J. Gillingham, manager of Schlumberger Surenco; J. De Menil, president of Schlumberger Overseas; M. Schlumberger, and L. A. Allaud, chief engineer in El Tigre.

New West Texas Division Manager Is Appointed by Dia-Log Company

Dia-Log Company has appointed Leo Bell as West Texas division manager, with headquarters at 2004 West Second Street, Odessa, Texas. Bell has been in the drilling end of the petroleum industry since he attended the University of Oklahoma. For several years he was employed in field work in the drilling departments of various operating companies. Later he was associated with the Permian Mud Service for three years as mud engineer, and then became an instructor in the Kilgore Junior College training program on oil field practices. He resigned his Kilgore post to join Dia-Log in June, 1948.

Leo Bell

Roebling Company Makes Changes In Oil Field Sales Personnel

John A. Roebling's Sons Company, Trenton, N. J., announced the following changes in its oil field sales staff: James E. Grimwood, formerly of Olney, Ill., has been transferred to Pittsburgh, Penn. His territory will include New York, Pennsylvania, West Virginia, Eastern Ohio and Eastern Kentucky.

Thomas J. Harrison replaces Grimwood in Olney and will represent the company in Western Kentucky, Indiana, Illinois and Michigan. William Gehrman, who formerly covered the Eastern oil fields, has been assigned to specialty work in the company's Cleveland office.

Empire Trust Company

NEW YORK

Capital Funds $9,106,248.33
Total Resources $137,375,756.57

Directors

DEAN MATHEY
Chairman of the Board

FRANK V. BALDWIN
Retired

C. KENNETH BAXTER
Chairman of the Board
Deep Rock Oil Company

JOHN T. CAHILL
Cahill, Gordon, Zachry & Reindel

EVERETTE L. DeGOLYER
DeGolyer & MacNaughton
Dallas, Texas

GEORGE A. EASLEY
Vice President, Salt Dome Oil Corp.

DEAN S. EDMONDS
Pennie, Edmonds, Morton & Barrows

CHARLES S. GARLAND
Alex, Brown & Sons
Baltimore, Maryland

ARCHIBALD A. GULICK
Alexander & Green

PAUL H. HUDSON
Executive Vice President and Secretary

GEORGE S. LEISURE
Donovan, Leisure, Newton, Lombard & Irvine
New York

JOHN L. LOEB, Partner
Carl M. Loeb, Rhoades & Co.

HENRY C. BRUNIE
President

GRAHAM D. MATTISON
Dominick & Dominick, New York

DONALD H. McLAUGHLIN
President, Homestake Mining Co.

JULIAN S. MYRICK
Vice President, Mutual Life Insurance Co.

CLENDENIN J. RYAN
President, Big Horn Cattle Co. of Colorado

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Fifth Avenue Office
580 FIFTH AVENUE

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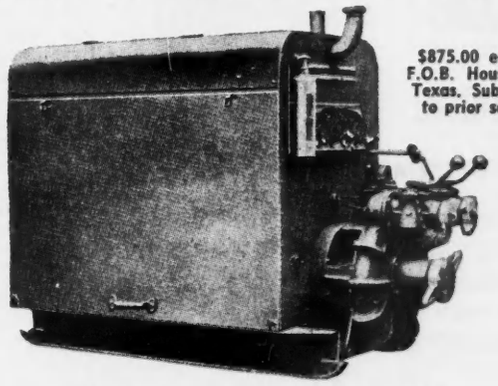
Condensed Statement of Condition, Dec. 31, 1948, available upon request.

FIRE PROTECTION!

Jetting—Transfer Work—Irrigation

We offer NEW surplus CHRYSLER-HALE Centrifugal Pumpers at approximately 50% of original purchase price.



$875.00 each F.O.B. Houston, Texas. Subject to prior sale

PUMP DATA

Hale Model OCD 1001
500 GPM—150 PSI—346 Ft. Hd.
HALE Ejector Priming
4" Suction — 2½" Discharges
N.S. Threads
Compact — Efficient
Quick opening valve on each discharge

ENGINE DATA

Chrysler T-118 (Ind. 7)
6 Cylinder
3-7/16" x 4¼" B & S
236 Cu. Inches Displ.
Radiator
Starting Equipment
Battery

NEW - BOXED

Immediate Delivery—Shipping Weight 1,950#

HALLORAN Equipment Co.

431 Kress Bldg. Houston 2, Texas Phone Capitol 1447

BOWEN AUTOMATIC LINE WIPER No. 8000

Bore of Body	2¾"
Connection	3"
For Line sizes	3/16 to ⅞"

for

SWABBING - BAILING
WIRE LINE CORING

*Wipes the line clean
*Keeps the floor clean
*Eliminates Fire Hazard
*Conserves Oil, Gas, or Drilling Fluid
Sturdily Constructed
Self Adjusting
Entirely Automatic
Trouble Free

Other models including Casing Sizes and Special Purpose Types are available and in stock.

Complete details will be mailed on request

THROUGH YOUR SUPPLY STORE ANYWHERE

BOWEN CO. of TEXAS, INC.

Office: 2429 Crockett St., P. O. Box 1025, HOUSTON 1, TEXAS, Phone A. 8-4568
—Odessa, Texas, Phone 789—Midland, Texas, Phone 1439.
Houma, La., Phone 6709—Oklahoma City, Phone 6-8087

Oscar R. Burden Named President Of Pacific Pipe Line, Engineers

Oscar R. Burden has been named president of Pacific Pipe Line and Engineers, Ltd., a California corporation with headquarters in Los Angeles. Burden served as division superintendent of the Texas Company and as vice president and general manager of Panhandle Producing and Refining Company, Wichita Falls, Texas. In 1942, he became an independent contract driller and pipe line constructor, before being appointed general superintendent in charge of laying the "Big Inch" oil line from Texas to New York. Since World War II, he has spent much time in the Near East, where he was in charge of oil installations of Trans-Arabian Pipe Line Company.

The corporation which he now heads has six branch offices besides the main office in Los Angeles. They are at El Cerrito, Bakersfield, Santa Maria, Fresno, North Hollywood and Avenal, Calif.

W. J. Rogers Appointed

W. J. (Bill) Rogers has been named field and sales coordinator for Oklahoma and North Texas areas for Mud Control Laboratories of Oklahoma City.

F. S. Fobes

F. A. Thorne

Baker Oil Tools, Inc., Promotes F. S. Fobes and F. A. Thorne

Baker Oil Tools, Inc., has appointed F. S. (Bud) Fobes assistant sales manager, Western division. Fobes has been associated with Baker since 1940, with time out for four years service as a lieutenant in the U. S. Navy during World War II.

Succeeding Fobes as director of advertising and publicity is Frank A. Thorne, who has been connected with the company since November, 1947. Thorne was staff writer with Webster Training Service for two years, and served ten years as director of public relations and employee relations for U. S. Engineers department at various California locations.

Dresser Manufacturing Appoints Paul Marx Corrosion Engineer

Dresser Manufacturing Division, Bradford, Penn., has appointed Paul F. Marx corrosion engineer. He will supervise corrosion studies at Bradford and will also be available for consultation on special corrosion prevention projects in the field.

Paul F. Marx

Marx was one of the first members of the National Association of Corrosion Engineers. In 1930 he inaugurated the corrosion development for the Natural Gas Pipeline Company of America. He formerly was chief corrosion engineer for the Northern Natural Gas Company at Omaha, and during the war years was technical engineer with the U. S. Maritime Commission at Washington, D. C. Before joining Dresser in 1948, Marx was chief corrosion engineer for Williams Brothers Corporation, maintainers of the "Big Inch" pipe line.

Baroid Executive Named

George B. Coale has been appointed assistant general manager of National Lead Company's Baroid Sales Division. He joined the company in 1935 as chief engineer of the Sayreville factory power plant. After two years he became mechanical superintendent at the plant, and then spent five years in the Navy. He returned to National Lead in 1945 as assistant chief engineer, and was named chief engineer of the company on January 1, 1949.

A NEW DAY IN FARMING AND RANCHING WITH

OAKS SPRINKLER IRRIGATION

FACTS ABOUT OAKS SPRINKLER IRRIGATION

- ★ All-aluminum, rustproof. Needs no storage or painting.
- ★ Lightweight, portable, efficient. Saves time, labor and water.
- ★ Installed and serviced by Oaks experts. Dependable, trouble-free.
- ★ Aluminum pipe ideal for transporting water for other uses.

OAKS
IRRIGATION EQUIPMENT CO.
PHARR, TEXAS

PORTABLE ALUMINUM SYSTEMS GIVE TROUBLE-FREE SERVICE

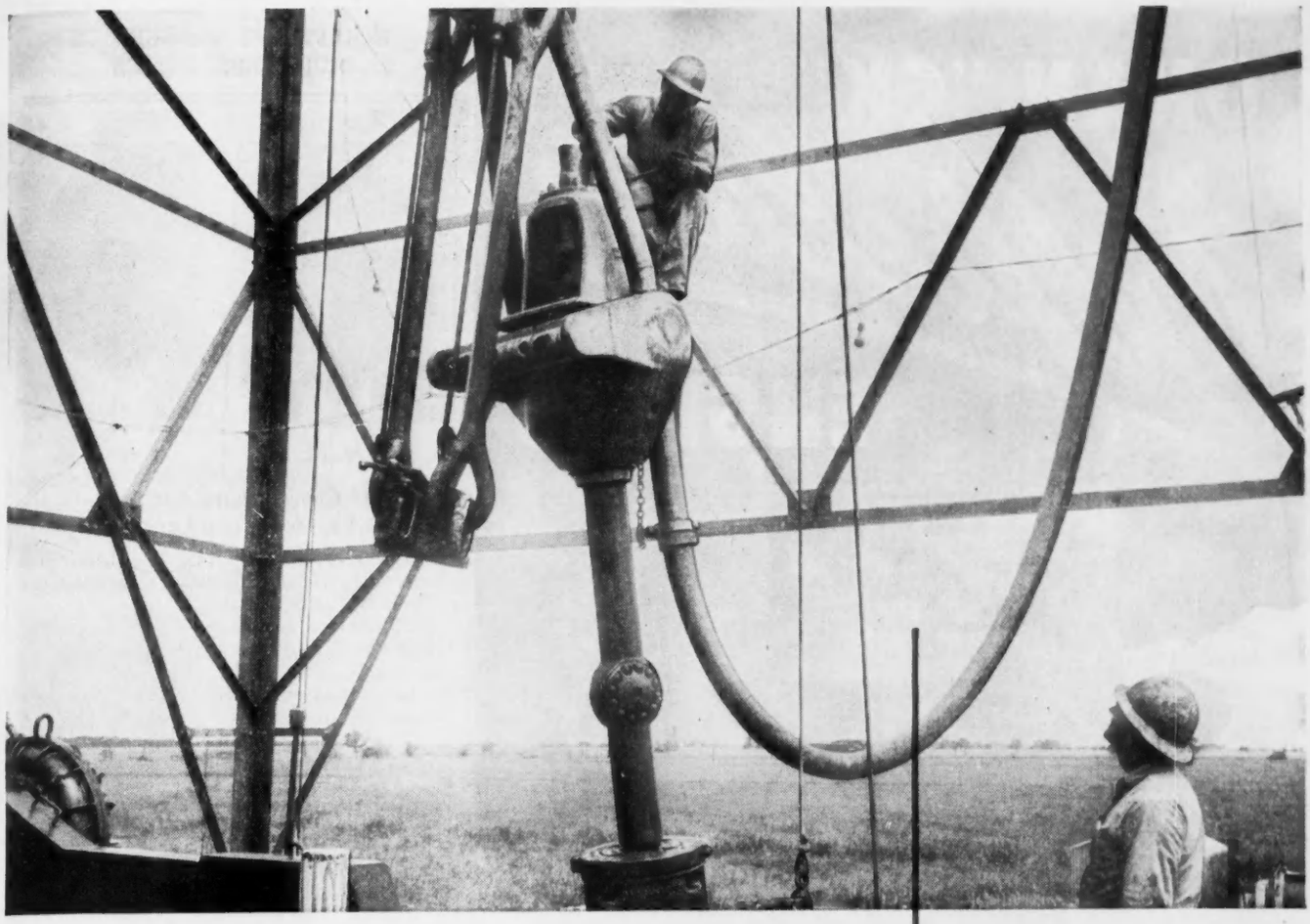
You'll have greater yields, and be sure of a crop, by installing Oaks Portable Sprinkler Irrigation. Then you'll be able to supply water when and where you want it, regardless of weather.

You can change your pasture program from "acres-to-the-cow" to "cows-to-the-acre" with irrigated pastures.

Oaks systems operate from any type of water source; need no ditches or leveling; make rough or hilly land productive.

Write us briefly describing your farm or ranch and we will give you definite information and expert recommendations.

AVAILABLE IMMEDIATELY! WRITE FOR COMPLETE INFORMATION



Boost drilling efficiency... cut drilling costs

Use time-proved Hewitt Rotary Drilling Hose . . . engineered for your job!

Consider the way Hewitt Rotary Drilling Hose is built and you'll see why it gives trouble-free operation.

Take Hewitt's famous Monarch brand, for example. Its special-purpose synthetic rubber tube resists abrasive muds and oil. Its high-tensile duck carcass (reinforced by three layers of braided bead wire), withstands high pressures, yet retains extreme flexibility when hung in the derrick. And its tough cover fights stripping action... resists abrasion.

You see, all materials used in Hewitt Rotary Drilling Hose are especially selected to provide longer, more useful hose life. That applies to all three types—Monarch brand for deep well drilling, Ajax for medium depth drilling, Conservo for slim hole drilling.

Write today for detailed information. Address Hewitt Rubber Division, 240 Kensington Avenue, Buffalo 5, New York. Or consult your nearest Hewitt distributor listed below:

Mid-Continent Supply Company

Norvell-Wilder Supply Company

Jarecki Manufacturing Company

Standard Supply & Hardware Co.

Bethlehem Supply Co. of California

HEWITT

ROTARY DRILLING HOSE

You Can't Buy Better Hose for Oil Well Drilling!

❶ ***Guaranteed test pressure!*** Monarch Rotary Drilling Hose is guaranteed on delivery to withstand test pressure of 5000 lbs. per square inch; Ajax, 4000 lbs.; Conservo, 3000 lbs. for 2¼" I.D.; 2,000 lbs. for 3".

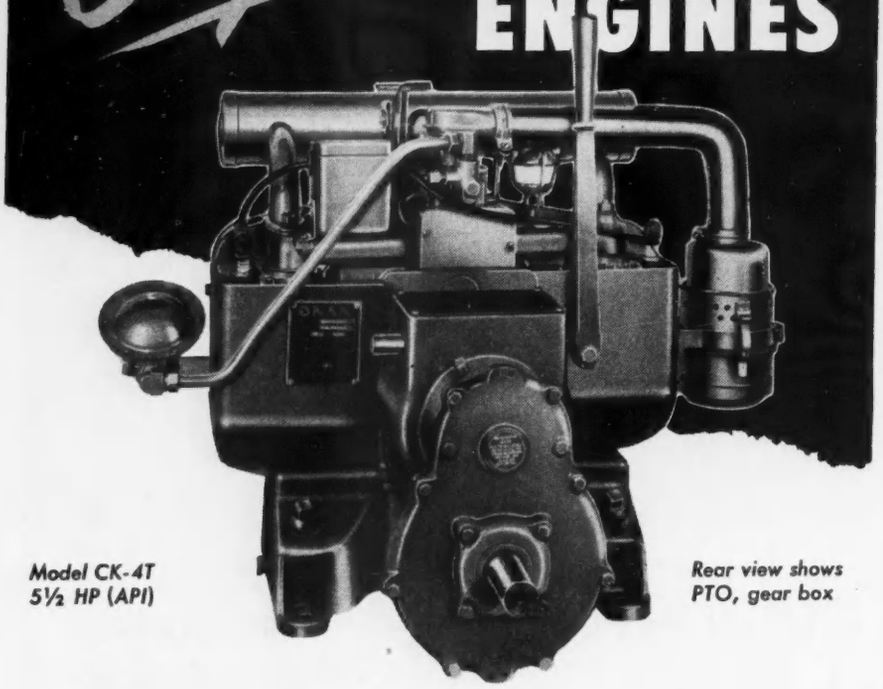
❷ ***Leakproof couplings!*** Hewitt built-in couplings assure unrestricted, completely rubber-lined fluidway. No external clamps!

❸ ***Special Inner Tube!*** The special-purpose, oil-resisting inner tube is specially compounded to resist abrasion and oil emulsion drilling mud. Tube, carcass, cover, couplings built to work as single unit.

❹ ***Fits your needs!*** Available in three types—Monarch 3-wire reinforcement, Ajax 2-wire and Conservo 2-wire.

HEWITT RUBBER DIVISION **HEWITT-ROBINS INCORPORATED**

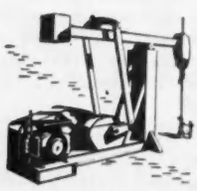
ONAN "CK" Oilfielder ENGINES



Model CK-4T
5½ HP (API)

Rear view shows PTO, gear box

Built for Continuous Duty on Tough Pumping Jobs!

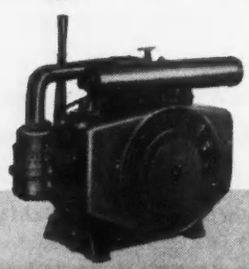


Do you have a job for a 5½ HP roughneck? Here's a dependable 1000-inch-pound torque engine that will do a job for you day-in and day-out with minimum maintenance and attention. No cooling problem because it's air-cooled. Little or no sludging. Has features of an engine many times its size. Smoother-running because of its twin-cylinder, horizontally-opposed design, the Onan "CK" Oilfielder gives lasting service on the toughest jobs.

Full pressure lubrication by gear-type oil pump. Runs on either gas or gasoline. Check with your supply house or write.

ONAN OILFIELDER ENGINE—*5½ HP.*
ONAN ELECTRIC PLANTS—*A.C.: 350 to 35,000 watts. D.C.: 750 to 15,000 watts. Gas-gasoline and Diesel models.*

D. W. ONAN & SONS INC.
5350 Royalston Ave. Minneapolis 5, Minn.



- 1000-inch-pound torque
- 5½ HP continuous duty (by API formula)
- 960-ft. piston speed
- 525 PTO shaft speed through 4.1 gear reduction
- Over-center dry disc clutch
- 4-quart oil sump
- Air-cooled by large axial-flow blower.

Onan PRODUCTS

ENGINES & ELECTRIC PLANTS

EQUIPMENT and SERVICE SUPPLIERS' NOTES

O. M. Van Dyke

G. H. Moore

Magnet Cove Barium Appoints Van Dyke, Moore and Lancaster

Orien W. Van Dyke has been promoted to vice president of Magnet Cove Barium Corporation, producers of Magcobar drilling mud products. Van Dyke was graduated from Iowa State College with a degree in chemical engineering, and joined the Philadelphia Quartz Company to promote the use of sodium silicate in the oil fields. He joined Magcobar in 1944 as chief engineer, and was made distribution manager in 1946.

E. H. Lancaster

George H. Moore has been named Magcobar sales manager. Moore was graduated from Texas A. & M. College and served as a colonel in the U. S. Army. For many years Moore was with Baroid Sales Division of the National Lead Company.

E. H. Lancaster, Jr., has joined Magcobar as manager of field service. Lancaster attended Rice Institute, where he received a master's degree in chemical engineering. For 13 years he with with Humble Oil & Refining Company in the Drilling Engineering and Drilling Mud Engineering departments.

George W. Stroup, Jr., Joins Nelson Electric Manufacturing Sales Force

George W. Stroup, Jr., has joined Nelson Electric Manufacturing Company, Tulsa, as a sales engineer. He was formerly with Roach Equipment Manufacturing Company and Buda Engine Sales and Service, Inc. He studied mechanical engineering at Oklahoma A. & M. College, and served in World War II as a naval aviation fighter pilot. Receiving his wings in 1943, he was assigned to the U.S.S. Midway, from which he participated in strikes on Saipan, Tinian, Guam, Morotai and the Philippines. He was released from active duty in 1946.

G. W. Stroup, Jr.

EQUIPMENT and SERVICE SUPPLIERS' NOTES

Hill D. Wilson

P. F. Matlock

Matlock and Wilson Organize Houston Well Screen Company

P. F. Matlock and Hill D. Wilson have purchased the capital stock of the Houston Welding & Machine Company, manufacturers of oil well and water well screen. The firm name has been changed to Houston Well Screen Company.

Matlock has been sales manager for Howard Smith Company for the past 18 years. He was with Layne and Bowler Company as purchasing agent in the Sales and Production department. One of the organizers of the Corbett Corporation and the Kinzbach Tool Company, Matlock was vice president of each organization for nine years.

Wilson was graduated from Texas A. & M. College in 1926 with a degree in mechanical engineering. Since graduation he has been shop superintendent for Howard Smith Company. During World War II he served in the Navy, stationed at the Mare Island Navy Yard as assistant superintendent of shops. He was released from active duty with the rank of lieutenant commander.

District Sales Representative Appointed by R. G. LeTourneau

Jim Sevick has been named district sales representative for R. G. LeTourneau, Inc., in Oklahoma, Arkansas, Mississippi, Louisiana and western Tennessee. In these states he will give sales assistance to LeTourneau distributors, Kessler-Simon Machinery Company, Tri-State Equipment Company, Inc., and Watkins-Aldridge Equipment Company, Inc.

Jim Sevick

Sevick joined LeTourneau early in 1948 and has been at Oakland, Calif., for the past few months as assistant to LeTourneau's western sales manager.

Iverson Salesman Named

J. W. (Joe) McCarty has been appointed to the Iverson Supply Company's sales staff, with headquarters at the company's general offices in Tulsa. McCarty previously was associated with Franklin Supply Company, Bethlehem Supply Company and Manning, Maxwell and Moore, Inc.

Unless thread compounds are treated very much like physicians' prescriptions, they don't contain *all* properties required for complete protection against galling. A haphazard mixture *won't do* the job.

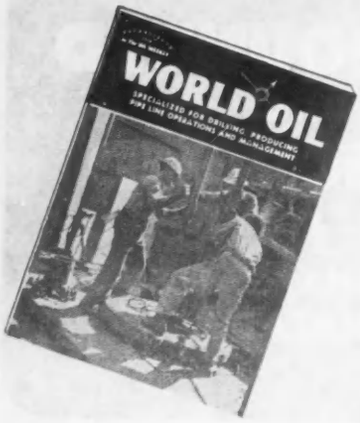
At WECO, thread compounds *are* treated like prescriptions. Carefully selected materials, each chosen for its ability to perform a certain vital function, are skillfully blended into compounds of the highest protective quality. Pure metallic bases . . . zinc in WECO No-Gall, lead in WECO Steel-Aid . . . are held in solution by neutral oils and grease binders that prevent any tendency to harden; tacky additives provide for adherence to wet, slick joints. *No compressible fillers are employed.*

GET THE FACTS on thread compounds from your WECO representative. He can show you why WECO compounds . . . Steel-Aid or No-Gall . . . provide unequalled protection. He'll also be happy to tell you about WECO Hi-Speed Seal, a permanent, non-hardening seal for casing, tubing and other threaded connections.

WECO THREAD COMPOUNDS ARE AVAILABLE AT YOUR SUPPLY STORE

WELL EQUIPMENT MFG. CORP.
Subsidiary of Chiksan Company
Houston 1, Texas
Exclusive Sales Representative Outside Mid-Continent Area
CHIKSAN COMPANY
Brea, Calif. New York 7
Export Sales: CHIKSAN EXPORT COMPANY, Brea, Calif. New York 7

WECO
Manufacturers and Distributors of Oilfield, Refining, Marine and Industrial Equipment



for the

READER

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The future will bring additional tough problems. And WORLD OIL will have the answers. We say that with confidence because our editors, engineers and technical writers are constantly in touch with men engaged in drilling, producing and pipe line work. New methods for new problems and new ways to tackle old problems are investigated and reported.

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NAME_____ POSITION_____

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Check branch of industry

☐ Drilling Contractor ☐ Individual Producer
☐ Producing Company ☐ Manufacturing
☐ Pipe Line ☐ Supply

EQUIPMENT and SERVICE SUPPLIERS' NOTES

Horace P. Norman Is Appointed Head of Continental Personnel

The Continental Supply Company has appointed Horace P. Norman head of its Personnel department in Dallas. All functions of a personnel nature in connection with the general offices in Dallas will be under his supervision. Norman joined Continental in 1933 in the Dallas las office. In 1938 he became field auditor in the West Texas-New Mexico district, remaining in this capacity until 1948, with the exception of 3½ years leave of absence for service in the Navy as a lieutenant commander.

Horace P. Norman

W. G. Sharp, former manager of the Continental store at Houma, La., has been transferred to Harvey, La., as manager of the store there. He was succeeded by L. W. Todd, former bookkeeper at the Houma store.

Chicago Branch Office Added by Cooper-Bessemer Corporation

Cooper-Bessemer Corporation has expanded sales facilities through the addition of a Chicago branch office.

Robert S. Bowie

The new office in the People's Gas Building, will be under the direction of Robert S. Bowie, who has been associated with Cooper-Bessemer since 1936 in other sales capacities. He has been active in the Chicago area since 1946.

Bowie's activities will continue under the supervision of Charles L. White, district manager for Cooper-Bessemer in the North Central area. White's headquarters are in the company's Mount Vernon offices.

Cooper-Bessemer now maintains branch offices in all the main industrial cities of the country and in the principal nations throughout the world.

Koppers Company Metal Products Division Has New Sales Manager

McMillan Robinson has been made sales manager for the Metal Products Division of Koppers Company, Inc.

Robinson resigned as vice president of the Ocean City Manufacturing Company of Philadelphia to accept the Koppers position.

From 1932 to 1935 he was in retail buying and selling work in Chicago, and then joined Firestone Tire and Rubber Company. In 1942 he entered Navy service and was discharged in 1945 with the rank of lieutenant commander. Since that time he has been vice president and sales manager of Ocean City Manufacturing Company.

EQUIPMENT and SERVICE SUPPLIERS' NOTES

Lundquist Resigns Position As Iverson Supply Officer

H. M. Lundquist has resigned as secretary-treasurer of Iverson Supply Company. Lundquist had been an officer of the company since its inception in 1926.

Additional changes in the company include the moving of A. M. Iverson, of Salem, Ill., to Tulsa as executive vice president, and the election of Ed Robertson as secretary-treasurer. Robertson will also continue in his present capacity as sales manager.

Hugh B. Downing, a newcomer to the Iverson organization, has been appointed assistant treasurer and credit manager.

Store Managers Appointed By Oil Well Supply Company

S. M. Miller, manager of the Abilene, Texas, store since March, 1947, has been named manager of the Pampa, Texas, store of Oil Well Supply Company, U. S. Steel subsidiary. He previously was with Oilwell stores at Albany, Talco and Greggton, Texas, and El Dorado, Ark.

C. V. Black, field representative at Abilene, will succeed him as manager of the Abilene store. Black joined Oilwell in 1946 and has served as warehouseman and later as storeman.

Harvey E. Smith has been named manager of the Oilwell store at Bridgeport, Ill. He was employed by Oilwell in 1945 as storeman in the Salem, Ill., store. He has been storeman in the Bridgeport store since 1947.

R. R. Longnecker has been appointed to district engineer-production equipment in the South Louisiana-Mississippi district. He joined Oilwell's Engineering department in 1937. After serving five years with the U. S. Army Corps of Engineers, he rejoined Oilwell in 1946 as assistant district engineer, Subsurface department, the position he leaves.

Harold C. Nicholson was named manager of the Natchez, Miss., store and James A. Brunnemer was made manager of the McPherson, Kansas, store. Nicholson, who joined Oilwell in 1920, has been field representative in Houston since April. Brunnemer, who has served with Oilwell since 1946, has been storeman in the Russell, Kansas, store since 1947.

Shifting of Three Key Men Announced by Mack Trucks

T. J. Zeller has been promoted to factory manager of the Allentown, Penn., plant of Mack Trucks, Inc., succeeding C. J. Moran, who has been transferred to Los Angeles. A. C. Schliewen will replace Zeller as manager of the Plainfield, N. J., plant.

Zeller joined Mack 25 years ago as tool designer and since has served as assistant testing engineer, chief bus engineer, production engineer, and Plainfield plant superintendent.

Schliewen went to Mack in 1933 as a tester in the Plainfield laboratory. He has been chief inspector for the Plainfield plant since 1945.

BUTLER BOLTED TANKS

ARE AVAILABLE NOW For Prompt Delivery

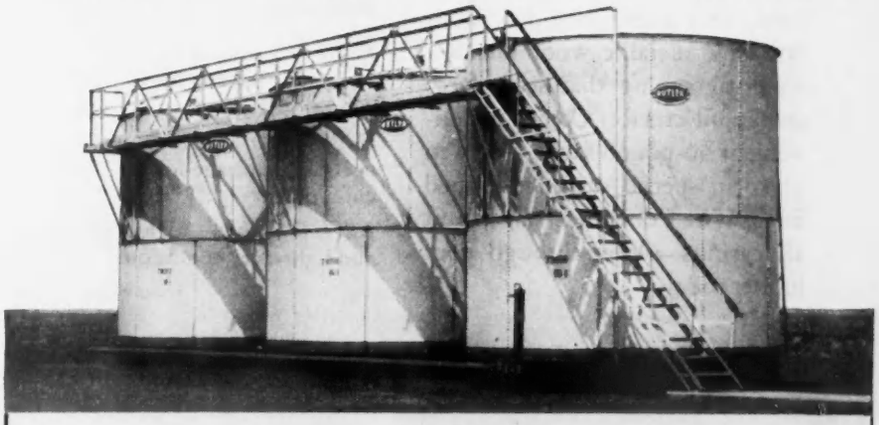
Here's good news for oil men everywhere! Larger supplies of top quality steel are available for bolted tank fabrication, and production lines at Butler are turning out more and more of these adaptable, long-life tanks.

For safe, oiltight storage, Butler Bolted Tanks have always been first in demand. Their ease of erection, speedy dismantling and reerection, and extra strength mean greater economy in oilfield use. Right now, Butler tanks are in good supply—and will continue to be as long as quality steel is available.

Butler oilfield organizations are ready to furnish you speedy, erection service in the field. Call the one nearest you today!

BUTLER MANUFACTURING COMPANY

Kansas City, Mo. Galesburg, Ill. Richmond, Calif. Minneapolis, Minn.



Call These Experts for Prompt Service

AMERICAN PIPE & SUPPLY CO.
Denver, and Rangely, Colo.
Casper, Wyo.
Cut Bank, Mont.

HARRY G. MILLER
El Dorado, Ark.

BUTLER

UNION TANK & SUPPLY CO.
Fort Worth, Houston, Odessa,
Alice, Tyler, Midland, Texas
Lafayette and Homer, La.
Great Bend, Kans.
Tulsa, Oklahoma City, Okla.
Hobbs, N. M., Jackson, Miss.

BOLTED TANKS • WALKWAYS • STAIRWAYS • UNIT HEATERS

Ardun Company Is Appointed Tulsa Distributor for Tube-Turn Equipment

Ardun Company of Tulsa has been appointed a distributor of Tube-Turn welding fittings and flanges. The firm is a partnership formed by H. W. (Doc) Arduser and Robert H. Duenner, Jr.

Arduser obtained his mechanical engineering degree at Purdue in 1931, and began his career with The Pure Oil Company in 1932, becoming chief production engineer of the Eastern Producing division. He founded Arduser & Company, specializing in the sale and servicing of oil and refinery equipment.

Duenner was graduated from Lehigh University in 1939 with a degree in industrial engineering, and did postgraduate work in metallurgy, mechanical engineering and finance. He joined the Bethlehem Steel Corporation at Bethlehem, Pa., and later was transferred to the sales staff at Tulsa. After serving in the Navy, he organized the Robert Duenner & Company, manufacturers' representatives.

F. R. Wheeler in New Post

F. R. Wheeler has joined the Chemical & Geological Laboratories at Casper as director of the Petroleum Engineering department. He was formerly a petroleum engineer with Engineering Laboratories, Inc., of Tulsa.

Bottom Water is a costly profit leak

Eagle Lead Wool

***stops* Bottom Water!**

You rule out the risk of oil-wasting bottom water shutdowns when you tamp Eagle Lead Wool in the hole. This finely stranded, non-corrosive metallic wool makes a water-tight plug that seals every crack and crevice. Comes in convenient 50-pound sacks—easy to place in special cartridge-shaped Eagle Wire Containers sized to fit all casings. Order through your jobber today.

These 3 Eagle Bearing Metals meet most requirements

Eagle Dreadnaught—for extreme speed and heavy-duty conditions.

Eagle Outlasta—for medium speed and average-load conditions.

Eagle Durable—for low speed and light-duty conditions.

EAGLE LEAD WOOL

Seals off Bottom Water—keeps 'em flowing!

THE EAGLE-PICHER COMPANY

Since 1843 EP PICHER

Thompson Is Appointed Research Director of Eagle-Picher Company

The Eagle-Picher Company has appointed Dr. A. Paul Thompson director of research, with headquarters at Joplin, Mo. Thompson fills the position left vacant by the death of Earle W. McMullen.

A. Paul Thompson

Thompson was formerly with the Mellon Institute of Industrial Research, where he held a Senior Fellowship since 1932. Prior to that time, he was associated with the International Nickel Company of Canada, with the General Chemical Company of New York as research engineer and consultant, and with the Anaconda Copper Mining Company as chief chemist.

American Steel & Wire Announces Duluth Works Improvement Program

Steel capacity at American Steel & Wire Company's Duluth Works will be increased 243,000 tons a year, or 35 percent, as a part of a replacement improvement and rebuilding program announced by B. E. Pheneger, district manager of operations for this U. S. Steel subsidiary. The Duluth Works turns out steel, semi-finished steel products, wire and manufacturers and merchant wire products.

To produce standard open hearth steel according to customer's specifications, two furnaces in the open hearth steel-producing department will be replaced. Rolling mill output of the Duluth Works will be increased from an annual total of 580,000 tons of billets produced on the plant's 40-28 inch mill to 784,000 tons. The program includes replacement of 57 coke ovens, and replacement of pot type annealing furnaces by modern circular bell-type furnaces, to permit closer heat control during the annealing period.

Representative in New York Appointed by Allis-Chalmers

A. Joseph Mestier, Jr., has been assigned to Allis-Chalmers New York district office as petroleum sales representative.

A petroleum geology graduate of Massachusetts Institute of Technology, Mestier joined Allis-Chalmers in 1946 following his discharge from the Army as a captain. Previous to entering MIT, he was employed for a year and a half by the British Union Oil Company in his native Barbados, British West Indies. He is a member of the AIME and the American Association of Petroleum Geologists.

Bowser Promotions Made

Gerald J. Klopfenstein has been appointed to the new post of assistant to the vice president and director of sales for Bowser, Inc., Fort Wayne, Ind. James E. Doelling has assumed Klopfenstein's former position as manager of the meter sales division.

EQUIPMENT and SERVICE SUPPLIERS' NOTES

E. L. Ludvigsen

J. Seton Gray

Fuller Manufacturing Company Promotes Officer Personnel

J. Seton Gray, president of the Fuller Manufacturing Company, Kalamazoo, Mich., for the past 14 years, has been named chairman of the board of directors. He has been associated with Fuller since 1932.

Succeeding Gray as president is E. L. Ludvigsen, formerly vice president and general manager of the Transmission division, who has been with Fuller for 20 years.

Harold E. Brey, formerly vice president and general manager of the Unit Drop Forge division, was made executive vice president. Prior to joining Fuller as manager of the Forge division, Brey was with the Universal Unit Power Shovel Corporation.

Two new vice presidents were named. William E. Niness is now vice president in charge of sales, and Thomas Backus, vice president in charge of engineering.

Frank C. McManus, formerly factory manager at Kalamazoo, has been named manager of the Transmission division, and E. L. Block was appointed manager of the Unit Drop Forge division.

Plomb Tool Company Names Works Manager for Los Angeles Plant

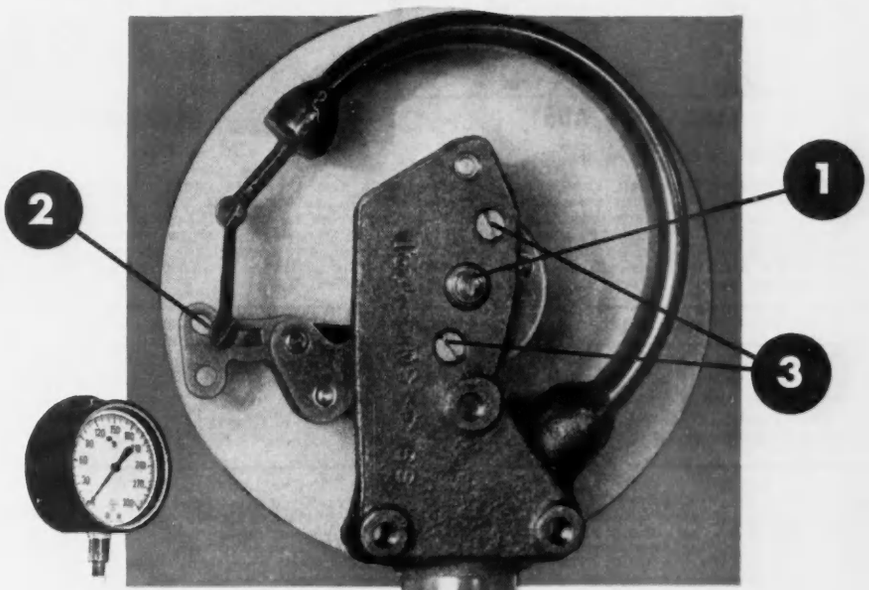
A. L. Hawley, formerly assistant works manager of Plomb Tool Company, has been appointed works manager of the main factory in Los Angeles. Hawley joined the company in 1936, working successively in the machine shop, tool room and Engineering department. He served as assistant factory superintendent, superintendent of time study, chief engineer, and assistant works manager.

A. L. Hawley

McCollum Firm Moves

McCollum Exploration Company and McCollum Laboratories, Inc., have moved to a new office building at 1025 South Shepherd Drive, Houston. Mailing address is P. O. Box, River Oaks Station, Houston 19, and telephone numbers are Jackson 2-3245 and Jackson 2-6905.

The Easiest Gage to Calibrate!

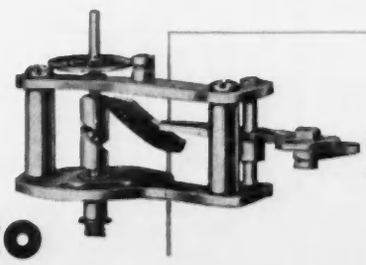


So says the Instrument Engineer

Here's Why: The external pointer set (1) is handy and very useful. In no other gage can the pointer be set without removing the glass and ring. Often a HELICOID gage can be made accurate simply by resetting the pointer.

If recalibration is necessary, the complete gage system is removed from the case. But there is no need to remove the pointer or dial. All adjustments are conveniently at the rear. For pointer travel, the link screw (2) is moved inward or outward in the cam slot. For scale linearity the movement is rotated by loosening screws (3). All this can be done *quickly* with a Helicoid gage. When recalibrating other gages, the pointer and dial must be removed frequently until calibration is attained. This takes more time and costs money.

The HELICOID gage is the easiest to calibrate and the easiest to keep in calibration.

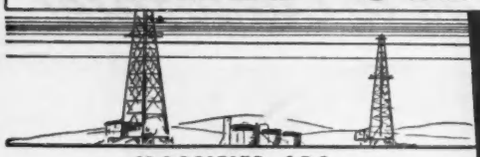


Only Helicoid Pressure Gages have the Helicoid Movement

ACCO

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE
Bridgeport 2, Connecticut

WORLD OIL'S Trading Post



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SERVICES · PERSONNEL · USED EQUIPMENT

RATES: Regular Classified (undisplayed) set in this size type: 10 cents per word. If Box Number is to be used count an additional six words. Replies forwarded without charge. Situation Wanted: 5 cents per word. Display advertisements, set in suitably larger type with ruled border: $9.00 per column inch per insertion. Situation Wanted: $4.50 per column inch. **All classified ads payable in advance.** 10% Discount if 3 or more insertions are ordered at one time. **COPY DEADLINE:** 5th of month preceding date of issue. Send copy and checks to: Trading Post Section, World Oil, P. O. Box 2608, Houston, Texas.

FOR SALE

■ **WELL** drilling spudders, beams, light rotaries, core drills, tools and casing. Used equipment at money saving prices. Spang and Mills new tools. Leschen lines. Everything for well drilling. Pressey & Son, Pueblo, Colo.

FOR SALE

■ FOR SALE. 2 - 5½ Keystones spudders complete with all tools. In A-1 condition. In east Kansas on water flood. With or without contract. Address: Box 7W, c/o World Oil, Houston, Texas.

FOR SALE:

40,000 ft. 18" OD x 5/16" Wall	Used Steel Pipe
40,000 ft. 16" OD x ¼" Wall	Used Steel Pipe
20,000 ft. 8⅝" OD Standard Weight	Used Steel Pipe
25,000 ft. 6⅝" OD Standard Weight	Used Steel Pipe
8,000 ft. 26" OD x ¼" to 5/16" Wall	New Substandard Electric Weld Steel Pipe
9,000 ft. 24" OD x ¼" Wall	New Substandard Electric Weld Steel Pipe
20,000 ft. 22" OD x ¼" Wall	New Substandard Electric Weld Steel Pipe
10,000 ft. 20" OD x ¼" Wall	New Substandard Electric Weld Steel Pipe

UTILITY & INDUSTRIAL SUPPLY CO., 921 Michigan Ave. E., Jackson, Michigan

For Sale
USED GAS ENGINES

37 - Stationary Gas Engines—2 cycle, with Belt Wheels

Make—Bessemer - Foose

Sizes range from 22 H.P. to 80 H.P.

For inspection, correspond with or call **South Penn Natural Gas Company,** Parkersburg, West Virginia.

For Sale
USED COMPRESSORS

20 Ingersoll-Rand Belt Driven, Type 10 COMPRESSOR UNITS:

Two stage 5½ x 10½ - 12" stroke
Two stage 10 x 18 - 12" stroke
Single stage size range from 6 x 8 to 17 x 12

For inspection, correspond with or call **South Penn Natural Gas Company, Parkersburg, West Virginia.**

AIRCRAFT FOR SALE
EXECUTIVE TYPE DOUGLAS A-26

The A-26 is the fastest and finest available executive air transportation. Five seats upholstered in blue and fawn. Complete executive interior. Owned by a prominent business man; used for personal and executive travel only. Available for inspection at Southern Airways Company, Municipal Airport, Atlanta, Georgia. Telephone Atlanta CA-7761. All inquiries will receive prompt attention.

2 - M.C. 350 Bethlehem rotary drilling rigs complete with 127' Lee C. Moore Cantilever (Jack-knife) derricks, less drill pipe and drill collars.
For further information write:

SHARP DRILLING COMPANY
Box 1271 - Midland, Texas

For Sale
USED PUMPS

19 - Geared, Triplex, Outside Packed PLUNGER PUMPS.

Make—National Transit - Denning - Gould. Sizes—6 x 8, 5½ x 8, 5 x 6, 7 x 10. For inspection, correspond with or call **South Penn Natural Gas Company,** Parkersburg, West Virginia.

It's New... Check It!

PIPE GRINDING MACHINE designed and built to give pipe line contractors maximum service in polishing the bevel on plain end pipe in preparation for welding. The machine can be placed on pipe easily and quickly, and will clean the bevel on 24-inch pipe in 15 seconds, whereas a man with file would have to work at least 15 minutes. The grinder is constructed for durability, light weight, effectiveness and economy. Electrically driven, it may be operated from electric welding machines on the line.

The Machine was perfected, and now being manufactured by

WICHITA TOOL REPAIR CO.
of Wichita Falls, Texas
Under license from O. R. Hall, inventor.

REAL ESTATE

■ FEE LAND on oil field flanks and oil prospects for sale; also plantations and ranches. W. K. Smith, Box 272, Franklin, Louisiana.

FOR SALE

FOR SALE

1 - 70 HP Superior Gas Engine
1 - 26 x 9 x 24 Worthington Simplex Hot Oil Pump with Forge Steel Head
1 - 18 x 8 x 18 Worthington Duplex Hot Oil Pump with Forge Steel Head
2 - 30 x 12 x 24 Worthington Duplex Hot Oil Pumps with Forge Steel Head
1 - 20 x 12 x 16 Blake Steam Pump
4 - 14 x 7 x 16 Carbondale Simplex Pumps
2 - 16 x 8 x 16 Carbondale Simplex Pumps

BANKOFF PIPE & SUPPLY COMPANY

P. O. Box 2301, Tulsa, Okla.—Ph: 6-2119

FOR RENT

■ ASKANIA MAGNETOMETERS. Rent or Sale. Repairing, parts, Field checking, New Magnetometers. Helmholtz coils. ROBERTSON CO., Jackson 2-5813, 5022 Ennis, Houston 4, Texas.

ATTENTION MANUFACTURERS AND MANUFACTURERS AGENTS

■ Warehouse and office space with telephone service available on South East 29th Street, main supply row, Oklahoma City, Okla. Address: Box 5, c/o World Oil, Houston, Texas.

HELP WANTED

■ WANTED—Geologist with at least six years' well completion experience in Texas Gulf Coast area. Address: Box 6, c/o World Oil, Houston, Texas.

ENGINEER: Midwest independent operating four refineries producing light oils, lubes, waxes and asphalts requires engineer with a minimum of 10 years refinery process and engineering design. Should be capable of carrying projects from economic study through process calculation, equipment design, and operating technique. Future for right man excellent. Give full particulars in first letter. Replies held confidential. Address: Box 4W, c/o World Oil, Houston, Texas.

PETROLEUM SALES EXECUTIVE: Large midwest independent has immediate opening for experienced bright stocks and neutrals sales executive. Unusual opportunity. In replying give full information stating age, education, experience, salary required. Replies will be held confidential. Address: Box 8W, c/o World Oil, Houston, Texas.

SITUATIONS WANTED

■ **CHICAGO EXECUTIVE available for part time responsibility with growing concern maintaining or contemplating Chicago headquarters. Well qualified in accounting, taxation, office and corporate procedures. Address: Box 82W, c/o World Oil, Houston, Texas.**

■ Representative in Louisiana, Arkansas, and Texas. Young (30), Energetic, Highly Intelligent, College Bred, Good Math Background. Excellent Sales Training and Experience. Widely acquainted among executives in above area. Write 5332 Virginia, Shreveport, Louisiana.

New Books and Maps

Petroleum Production

"Petroleum Production, Volume 5" is the fifth and concluding volume of an extensive review on petroleum production by an outstanding authority. The author, Park J. Jones, a consultant since 1944, studied all phases of oil and gas production. Volume 1, published in 1946, dealt with Mechanics of Production; Volume 2, Optimum Rate of Production; Volume 3, Oil Production by Water; and Volume 4, Condensate Production and Cycling. Volume 5 discusses the production of oil by gas injection and water flooding.

Terms and reservoir characteristics involved are defined and explained. Formulae employed in this study are discussed step by step as they are developed. Mechanics of oil displacement by gas are given a mathematical treatment, clarified by diagrams and charts. A chapter is devoted to the separation of condensates and their extraction from "wet" gases. The effect of reservoir pressure on the vaporization of liquid hydrocarbons and the resulting change in chemical composition of the oil is presented.

Of considerable interest to the reservoir engineer is a treatise on pressure maintenance with gas. Wide experience gained in numerous studies of this type operation in the past few years brings the reader the latest thinking on the subject. Chapter 6 deals with declining reservoir pressures, and is limited to oil recovery by expansion and by injection of the gas produced from the reservoirs, which may, or may not, have a primary gas cap. The author devotes 46 pages to the increasing important subject of water flooding. Factors which must be considered in water flood programs are studied, and sample calculations are given for estimating oil recoverable by flooding.

Part 2 of the book is concerned with oil production by gas and includes a study of radial reservoirs and traps. The concluding chapter deals with the economics of water flooding. An appendix contains tables of tentative K values for oil.

Book Department, Gulf Publishing Company, P. O. Box 2608, Houston 1, Texas.

Laws and Petroleum Resources

"Antitrust Laws, et al. v. Unit Operation of Oil or Gas Pools," by Robert E. Hardwicke of Fort Worth, is a 300-page volume which traces the history of the conservation movement. The movement received a strong stimulus in 1924 when Henry L. Doherty vigorously insisted that oil production practices were distressingly wasteful, and that the only adequate remedy was unit operations under federal laws. The author observes that the discussion and studies which followed the Doherty statement served to outline production problems confronting the industry.

An account is given of the efforts to solve the problems, including a sketch of the activities of federal and state governments, and the activities of such organizations as the Federal Oil Conservation Board, American Petroleum Institute, American Bar Association (Mineral Section), American Institute of Mining & Metallurgical Engineers, Mid-Continent Oil & Gas Association, and Interstate Oil Compact Commission. The factors which cause the present unusual interest in unit operations, voluntary and compulsory, especially with respect to condensate gas pools and all types of secondary recovery operations, are discussed.

The analytical discussion of the problems and the solutions suggested, with special emphasis on the effect of antitrust laws and other laws, state and federal, is profusely documented.

A complete subject index, table of cases, listing of constitutions, statutes, books and articles cited, and table of proper names are included.

American Institute of Mining and Metallurgical Engineers, 29 West 39th Street, New York 18, $1.50.

Petroleum Engineers' Handbook

The third revised edition of "Practical Petroleum Engineers' Handbook" by Joseph Zaba and W. T. Doherty is available.

This book was first published in 1937. Primarily, it consists of a large number of charts, tables, formulae and other pertinent data of value in solving petroleum engineering problems.

Book Department, Gulf Publishing Company, P. O. Drawer 2608, Houston 1, Texas.

SITUATIONS WANTED

■ Experienced Lease and land man desires connection with Oil or Gas Company who plan to operate in the San Joaquin or Sacramento Valleys, California. Thoroughly familiar with these areas. Presently self employed. Salary $500 a month and expenses. Reply P. O. Box 1024, Marysville, California.

WANTED TO BUY

EQUIPMENT WANTED

■ Am interested in purchasing good second-hand, unit 15 rig, with either 2 or 3 motor compound. Please send description, price, and location to World Oil, Box 2608, Houston 1, Texas.

LEASES, DRILLING, ACREAGE, ETC.

■ SEE A. L. BOWLES, ADA, OKLAHOMA, FOR SHALLOW DRILLING DEALS IN OKLAHOMA.

■ We will buy producing or non-producing oil royalties. Send particulars. Standard Security Co., 115 Broadway, New York 6.

ROYALTIES IN HOT AREAS!

■ Recent strikes have focused attention on Montana's deeper oil zones and major companies are moving in fast, drilling and leasing. We buy direct in the field, sell direct to our customers. Write LANDOWNERS ROYALTIES COMPANY, Box 1225, Great Falls, Montana.

■ Prospective new shallow, high gravity oil field, N. W. Ga. Mississippian-Devonian shale and limestone exposures. Good structural indications. Drilling deals considered. Dietzen, Rt. 3, St Elmo, Tenn.

LEASES IN SAN JUAN BASIN—NEW MEXICO

Have large spread of leases inside the Basin proper, all open for sale or drilling deals. Tom Bolack, Winfield, Kansas.

Bell TUBING SWABS

The New Standard for Efficiency and Economy

- Lift more fluid each trip.
- Long wearing reversible cups save you money.

2-Cup Swabs for shallow work.

4-Cup Flexible Swabs for deep swabbing

See Pages 2642-43 Composite Catalog
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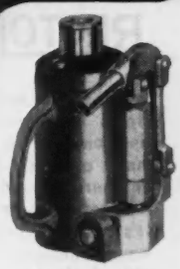
CUT TIME, CUT COSTS on TOUGH PULLING JOBS

Jenny pulls *through* center hole — torque is eliminated, power added.



FIVE MODELS! 30 to 100 Tons Capacity

Use the Hydraulic, No-Twist Power of the Simplex-Jenny

Makes even the most difficult pulling jobs an easy job for one man. Unique center hole action speeds pulling of valve seats, keys, wheels, gears, wrist pins, cylinder liners etc. The Simplex-Jenny is self contained, light in weight, but built for rugged, lasting service. Can also be used as a press (all models tapped for gauges) or as a conventional hydraulic jack.

SEND FOR BULLETIN: OIL 48

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Jacks

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1032 South Central Ave., Chicago 44, Ill.

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CABLE & STINE
WICHITA FALLS, TEXAS

EXPERIENCED PRACTICAL
AND TECHNICAL CONSULTING
PRODUCTION ENGINEERING
SERVICE

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SPECIALIZING
in
MODERN
SECONDARY
RECOVERY

On Mud Lines, Steam Lines
Oil and Gas Lines...It's Sure!

RECTORSEAL #1

Whether you are working on mud lines, steam lines, water lines or oil and gas lines on your rig, RECTORSEAL #1 can make every connection leak-proof, safe and sure! 10 years of service and industry acceptance means it's got to be good! It's easy to apply . . . a little goes a long way. It's dependable leak prevention for the life of the connection.

Ask your supply store for Rectorseal #1 by name.

Write:
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Dept. G
2215 Commerce St. Houston 2, Texas

RECTORSEAL
MAKING THE OIL INDUSTRY SAFER

SQUEAKS from the BULLWHEEL

Well, It's Thicker than Water

One morning a lone Irishman was at work near the top of a telephone pole, painting it a bright green when the pot of paint spilled and splashed on the sidewalk. A few minutes later another Irishman came along. He looked at the paint, then at his countryman, and inquired with anxiety in his tone, "Doherty, Doherty, hov ye had a himmerige?"

Just a Zephyr

A New Mexico dude ranch host was apologizing to his guests for what he called "an unusual spell" of wind that scalped a saddle shed, blew down numerous trees and kept the guests indoors. His guests looked skeptical. Everywhere they went, they said, people always claimed that the weather was "unusual."

"But this windy spell is unusual," defended the ranch host. "Why you can see for yourselves that it's blowed down trees that never was blowed down before!"

No Sales Resistance

A couple of farm boys brought a load of watermelons to town to peddle from door to door. At the first house a good-looking girl answered the door. She asked the price of the melons and was told they were 75 cents each.

You wouldn't charge ME 75 cents, would you?" asked the girl, looking at them with liquid eyes and turning on all her charm.

"Listen, lady," said the boy, "yesterday we gave away a whole load of peaches and we just gotta sell these watermelons."

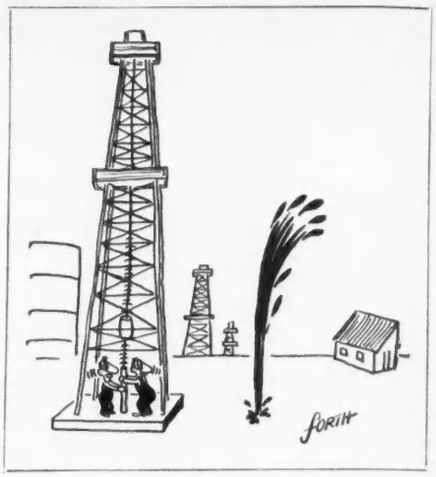
Annual Report

"Dere goes dat Many Jackson wid her ten pickaninnies. She sho do look repugnant."

"Lan' sakes! Again?"

A Brief Tale

Have you heard about the devil who backed into a lawnmower, then went into a liquor store because he heard they retailed spirits?



Exhibitionist!

"Not a day passes that my wife doesn't show her incompatability."

"Yeah, ain't it a shame the way women dress these days."

So There!

The bride's girl friend was asking her what was the biggest thrill in the whole proceedings.

"Well, there were lots of thrills," said the bride thoughtfully. "First, when we went to the license bureau, then when the minister pronounced us man and wife, and it was a real thrill signing the register Mr. and Mrs. But by far the biggest thrill was thumbing my nose at the house detective."

Some Pun

Said one broomstick to the other: "Let's be broommates so we can sweep together, dust for the fun of it."

A Little Education

Tommy came home proudly from his first day at school.

"What did you learn in school?" asked his mother.

"Nothing," said Tommy, then, seeing the look of disappointment on her face, he added, "But I learned a lot during recess!"

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Welding Saddles

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IMMEDIATE DELIVERY
OUTLET (OR NOZZLE) SIZES ¼" TO 16"
HEADER (OR LINE) SIZES UP TO 36"
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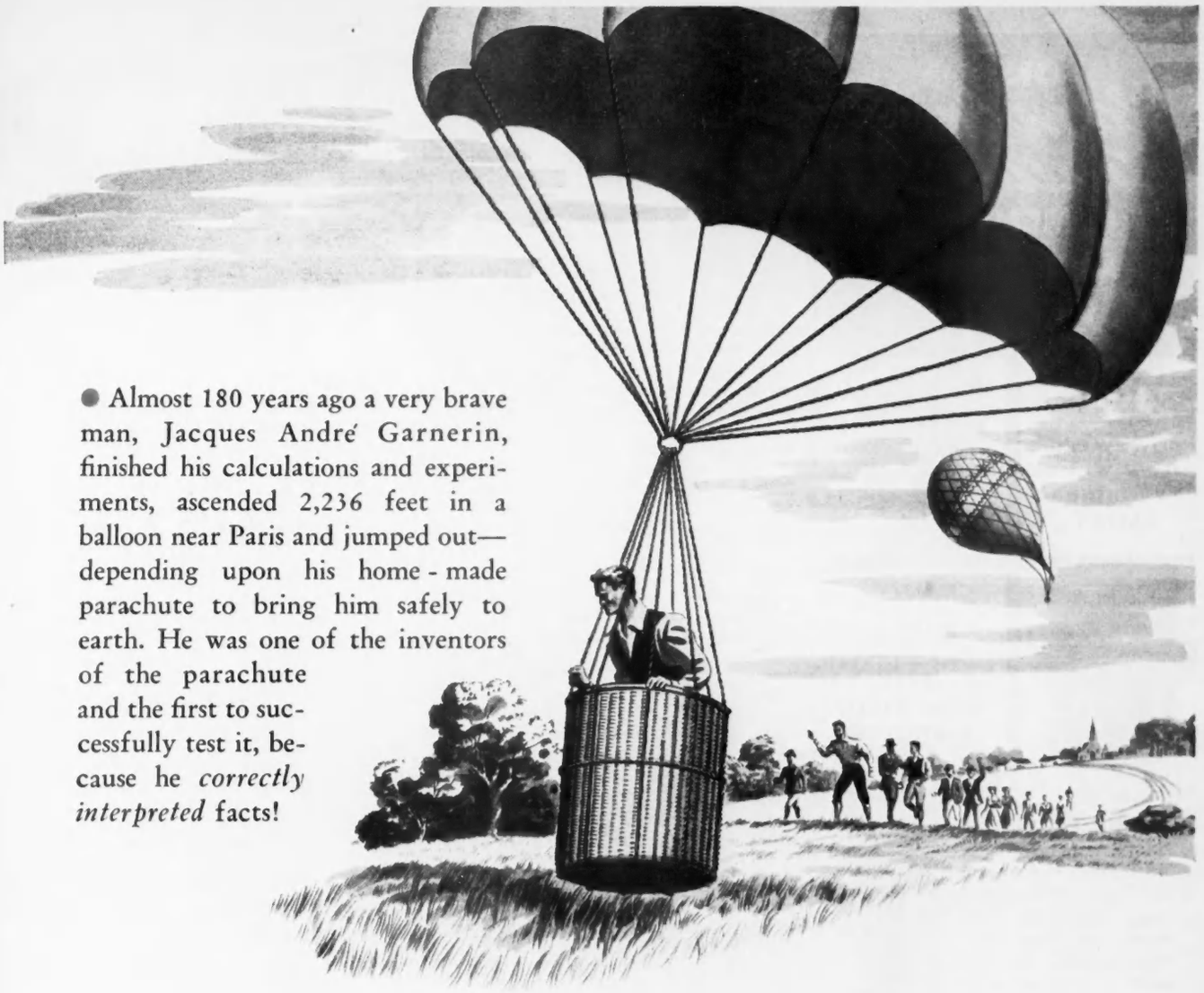

● Almost 180 years ago a very brave man, Jacques André Garnerin, finished his calculations and experiments, ascended 2,236 feet in a balloon near Paris and jumped out—depending upon his home-made parachute to bring him safely to earth. He was one of the inventors of the parachute and the first to successfully test it, because he *correctly interpreted* facts!

● And in today's business, especially in the costly drilling of oil wells, *correct interpretation* of the facts pays off. Good equipment, trained crews and correct interpretation of subsurface conditions—these have been the factors resulting in McCollum Exploration Company's leadership for over a quarter of a century.

McCOLLUM SINCE 1923
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DOMESTIC AND FOREIGN EXPLORATION

Pioneers in

Refraction Shooting • Reflection Shooting • Well Shooting • Marine Shooting

ONLY
Cameron
-Nuwell
CEMENTING
EQUIPMENT
PERMITS

FULL
DOWNWARD FLOW WHILE RUNNING CASING

FULL
LATERAL FLOW WHILE CEMENTING

FLOAT COLLAR

SHOE

CAMERON - NUWELL FLOAT COLLAR AND SHOE shown in cross-section. Note how the slotted cage in the Float Collar retains the large back-pressure ball, but the smaller diverter ball, shown entering shoe, readily passes thru the Float Collar to seat in the shoe and seal the axial hole.

Application of pump pressure shatters diaphragm which permits all fluid to flow through side ports.

With CAMERON-NUWELL cementing equipment, control of fluid-flow direction during cementing procedure is as simple as the manipulation of a two-way valve.

When running casing, the entire flow of fluid is directed *downward* through the nose of the Shoe at high velocity in order to wash down any bridges which might be encountered.

BUT — when the casing is landed, *lateral flow* is required for a good cement job.

Operators interested in obtaining a good primary cement job, fewer costly squeeze jobs, are invited to send for descriptive literature.

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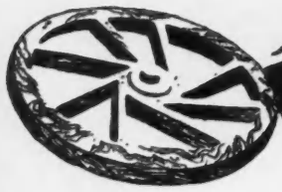

SQUEAKS from the BULLWHEEL

Just Practicing

A girl got a job with an advertising agency to distribute little boxes of candy free to the public. She had finished her day's work when she met an old friend whom she hadn't seen for a long time.

"Oh, Joan," said the friend, "I've just heard that you're going to be married."

"Yes, I am," replied Joan. "We're going to be married next month."

"How wonderful," said the interested friend. "What are you doing now?"

"Nothing much," was the reply. "Just giving away free samples."

Partly Cloudy

"Driving while intoxicated will cost you $10 and costs, and the next time you'll go to jail, understand?"

"Yes, your Honor, it's just like a weather report — fine today, cooler tomorrow."

A Little Shaver

Two revellers a bit the worse for wear approached a ticket office window. One was carrying his friend in his arms, staggering a little under the burden.

"Two tickets to Clarksville," he said.

"This is only the price of one ticket," replied the clerk. "What about your friend?"

"Why, he's only a baby," he declared.

"That fellow you're carrying?" demanded the ticket agent. "He's at least six feet tall, weighs 190 and has a beard as thick as a mattress."

The ticket buyer dropped his pal unceremoniously. "Willie, you idiot!" he howled, "I told you to shave!"

"I'm afraid you're taking the sign too literally."

Corny Joke

Baby Corn: "Mama, where did I come from?"

Mama Corn: "The stalk brought you."

Reading Matter

She was working her way through college selling Colliers, but all the boys wanted to take Liberties.

Self Service

"Do you serve women at this bar?"

"Nope, you gotta bring your own."